This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

HN 69T8 6

DYKE'S
AUTOMOBILE ENCYCLOPEDIA

G. 1003

Dyke's

Automobile Encyclopedia

SECOND EDITION REVISED AND ENLARGED

IN 40 PARTS
Including a Dictionary, Index and 175 Charts
TREATING ON
Construction, Operation, Repairing
of Automobiles and Gasoline Engines

By
A. L. DYKE, E. E.
MEMBER SOCIETY OF AUTOMOBILE ENGINEERS
Originator of the first Auto Supply Co. and publisher of the first book on Automobiles in America.

PUBLISHED BY
A. L. DYKE, PUBLISHER
Exporter and Importer
ST. LOUIS, U. S. A.

KG 1003

HARVARD
UNIVERSITY
LIBRARY

Copyright 1911
By A. L. DYKE, ST LOUIS, MO.
ALL RIGHTS RESERVED.

PREFACE

THIS Auto Instruction was prepared with the idea of presenting in clear, simple form, the principle upon which Gasoline Engines and Automobiles are operated and built, and to explain in detail all that an operator must understand in order that he may run and care for any make of car or gasoline engine.

The writer makes no attempt to treat the subject in a theoretical manner, his idea being to adhere strictly to the practical side of the subject.

The matter herein covers the explanation of all types of cars—not individually but in general. For instance: there are three types of drives employed to transmit the power from the engine to the rear axle, viz: The single chain, the double chain and the shaft or propeller drive.

There are three types of transmission in general use, viz: the old style progressive, the selective, and the planetary.

There are two types of clutches in general use, viz: the cone type placed in the fly wheel of the engine, the multiple disc type, and so on, covering each and every part of the car.

In this manner the readers learn the construction of the only principles in general use. The construction may vary, but the principle remains the same. Consequently when the reader masters the three principles involved he masters the construction of ALL types of automobiles, engines, ignitions, carburetors, etc.

A marked feature of this book is the inclusion of a large number of clear illustrations, chiefly of a diagrammatic nature in the form of charts.

These charts deal with the car and its parts. The gasoline engine and engine parts; such as various types of valves, cylinders, etc. Carburetion, ignition; both coil and magneto, low and high tension. Storage batteries. Cooling. Lubrication. Operation. Digest of troubles with a complete diagnosis. Repairs. Overhauling an engine. Questions asked and and answered and concludes with a dictionary and a complete index and specifications of all leading cars.

What might be termed the "practical" section of the book, under the head of operation and repairing, comprises numerous hints and full directions on the choice of driving, maintenance and repairing of a car, has been specialized.

TABLE OF CONTENTS

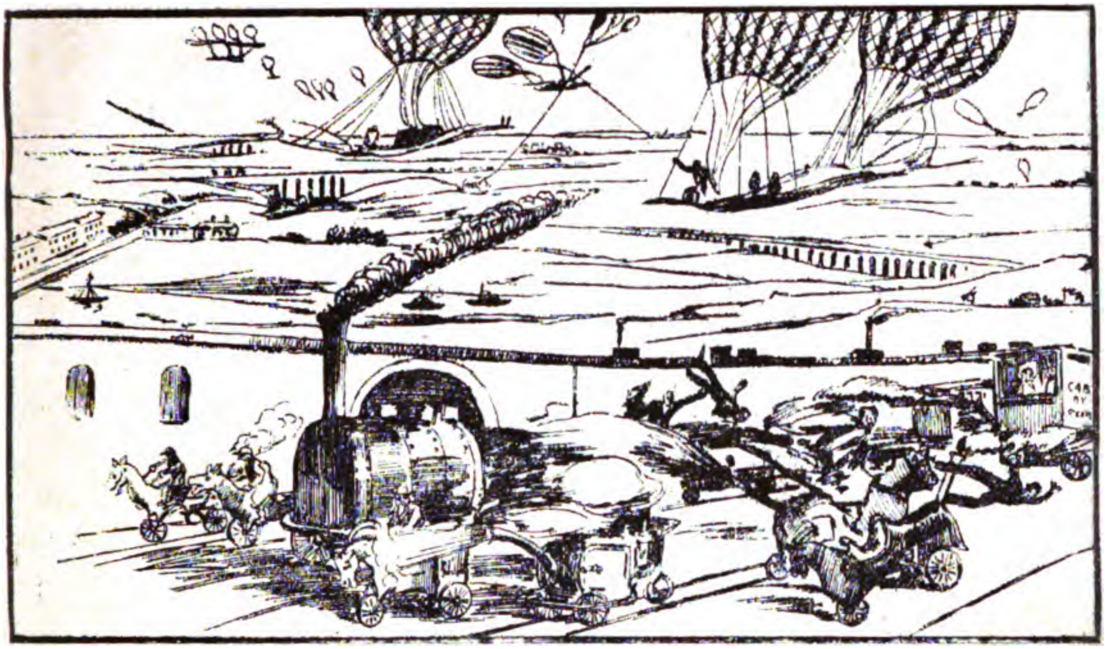
of

SUBJECTS TREATED IN THIS BOOK.

(See Index in the back of book.)

INSTRUCTION No. 1—The Car Complete—What Each Part Is For......... 1 to 10
INSTRUCTION No. 2—Drives—Single, Double Chain, Shaft Drive............ 10 to 17
INSTRUCTION No. 3—Steering, Springs, Brakes .... 17 to 29
INSTRUCTION No. 4—Axles, Differential .... 29 to 41
INSTRUCTION No. 5—Clutches .... 41 to 50
INSTRUCTION No. 6—Transmissions .... 50 to 68
INSTRUCTION No. 7—The Gasoline Engine .... 68 to 88
INSTRUCTION No. 8—Engine Parts .... 88 to 101
INSTRUCTION No. 9—Valve Timing ....101 to 107
INSTRUCTION No. 10—Engine Balance; How Cylinders Fire, etc...........108 to 125
INSTRUCTION No. 11—The "Cycle" Principle Explained ....125 to 128
INSTRUCTION No. 12—Carburetion ....128 to 164
INSTRUCTION No. 13—Electric Ignition ....164 to 176
INSTRUCTION No. 14—High Tension Coil Systems ....176 to 196
INSTRUCTION No. 15—Wiring and Connections ....196 to 206
INSTRUCTION No. 16—Ignition Timing ....206 to 212
INSTRUCTION No. 17—Magnetos ....212 to 220
INSTRUCTION No. 18—Low Tension Magnetos ....220 to 236
INSTRUCTION No. 19—High Tension Magnetos ....236 to 243
INSTRUCTION No. 20—Magneto Action—Principle and Construction.........243 to 260
INSTRUCTION No. 21—Setting Magnetos ....260 to 265
INSTRUCTION No. 22—Magneto Wiring Diagrams ....265 to 276
NISTRUCTION No. 23—Storage Batteries ....276 to 279
INSTRUCTION No. 24—Lighting a Car ....279 to 305
INSTRUCTION No. 25—Cooling ....305 to 317
INSTRUCTION No. 26—Lubrication ....317 to 325
INSTRUCTION No. 27—Operating a Car ....325 to 341
INSTRUCTION No. 28—Periodical Attention to a Car ....341 to 348
INSTRUCTION No. 29—Troubles Likely to Occur, and Remedy..............348 to 358
INSTRUCTION No. 30—Digest of All Troubles, with Diagnosis and Remedy..358 to 373
INSTRUCTION No. 31—Tires ....373 to 389
INSTRUCTION No. 32—Repairing Tires ....389 to 398
INSTRUCTION No. 33—Vulcanizing ....398 to 401
INSTRUCTION No. 34—Building a Garage ....401 to 413
INSTRUCTION No. 35—Repairing . ...413 to 461
INSTRUCTION No. 36—Rules of the Road. Gasoline Storage. Supplies for Touring. How to Select a Car. Insurance........461 to 468
INSTRUCTION No. 37—Digest of Auto Laws; All States and Canada.........468 to 477
INSTRUCTION No. 38—Horse Power Formulae. Tables. How to Read a Taximeter. Grades. Millimeters, etc.............477 to 481
INSTRUCTION No. 39—Steam Boilers. Steam Engines. Aircrafts...........481 to 485
INSTRUCTION No. 40—Dictionary. Specifications of All Cars.............485 to 496

NOTE—Use the index freely. Any trouble you may have, refer to the index.



' AN 1837 VISION OF THE FUTURE '

A PROPHECY OF THE PRESENT IN 1837

A glance at the illustration reproduced gives an idea of the splendid conception of the future had by the author of the article. True, modern day motive power vehicles do not present the grotesque appearance outlined in the picture; however, the idea is there, and the conception has been fully carried out, only on a more enlarged and modernized scale.

Following is the article just as it was published in a London paper May 1st, 1837, nearly seventy-five years ago.

WHAT WE ARE COMING TO, OR A LOOK INTO FUTURITY

"Those as live longest 'll see most, and I'm thinking those as come arter will have some changes to witness. Everything now is done by machinery—steam or gas—and if one could see into the womb of time, I'm blessed if I don't think as we should find that his majesty's army and navy will hereafter be hatched like chickens in an Egyptian oven; and the trouble of bringing up a family will be altogether superseded by the self-generating principle of matter. But 'no matter'; 'live and let live' is my maxim. Let us enjoy 'the ills we have' without 'flying to others we know not of'; let us hope the march of happiness will keep pace with the march of mind."

Farewell to old traveling, and hail to the time
  When cattle and drags will be quite superseded
And intellect's march, with a progress sublime,
  Will still hasten forward, by nothing impeded.

Of steam folk will then know the wonderful power,
  Applied in a manner ne'er thought of before;
An traveling with ease fifty miles in an hour,
  May wonder their ancestors ever went slower.

On railroads and viaducts thousands will throng,
  Every risk of collision and accident daring;
And ladies undauntingly dashing along,
  On cast-iron nags sally forth for an airing.

No longer content with discoveries below,
  Folks will daily hold converse with men in the moon;
And, spurning the earth, it will then be the go
  To dash thro' the clouds in a "patent balloon."

Great nations in those intellectual days
  For a new and improved mode of war will prepare;
And as soon as the wind they are able to raise,
  Will fiercely set to in the regions of air.

Then vessels of war, and for commerce on high,
  Thro' ether will hold their course steady and free,
Steered by pilots well skilled in the track of the sky,
  And when vessels will scarcely be seen on the sea,

"Come, who's for Calcutta?—no longer I'll stop—
  So. pilot, make ready to sever the rope;
At Madeira I've got a few parcels to drop,
  And for passengers call at the Cape of Good Hope.

"Come, friends, be alive, 'tis beginning to blow,
  And this easterly gale is confoundedly bleak,
My company says it is high time to go,
  And back I must be in the course of a week."

Thrice happy who live in such marvelous hours,
  When science shall shine all unclouded and clear,
While we boasting still of our wonderful powers,
  In knowledge and wisdom are all in the rear.

Then farewell to coaches and horses, alas!
  Doomed to pass with your drivers away like a dream,
Your glory eclips'd by ballooning and gas,
  And your splendid turn-out superseded by steam.

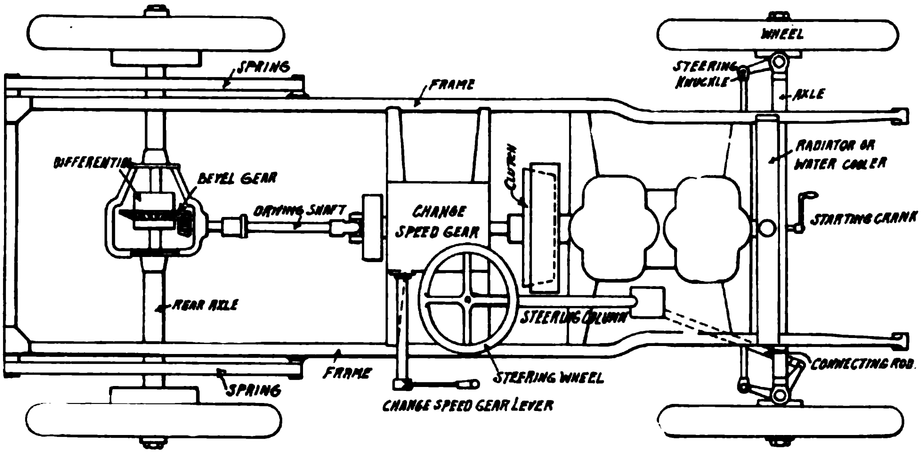


Figure 1—Propeller or Shaft driven car.

The Transmission is of the Sliding, Gear type.

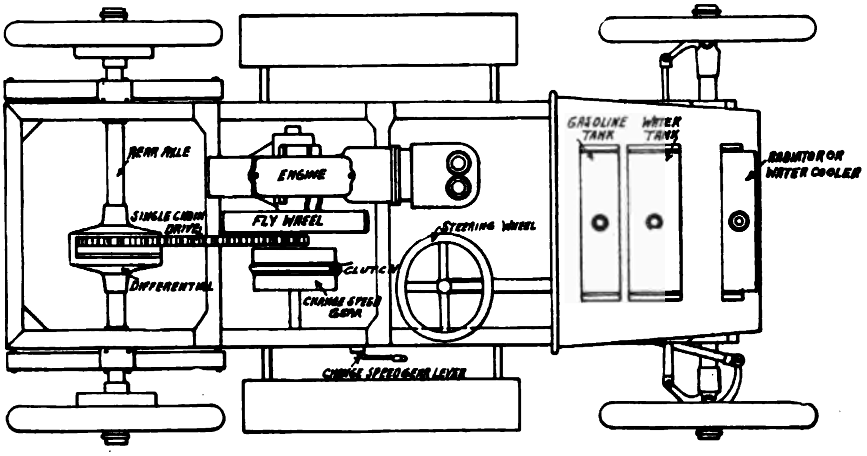


Figure 2—Single Chain driven car.

The Transmission is of the Planetary type.

Study the names of the parts of the Auto and their location.

CHART No. 1.

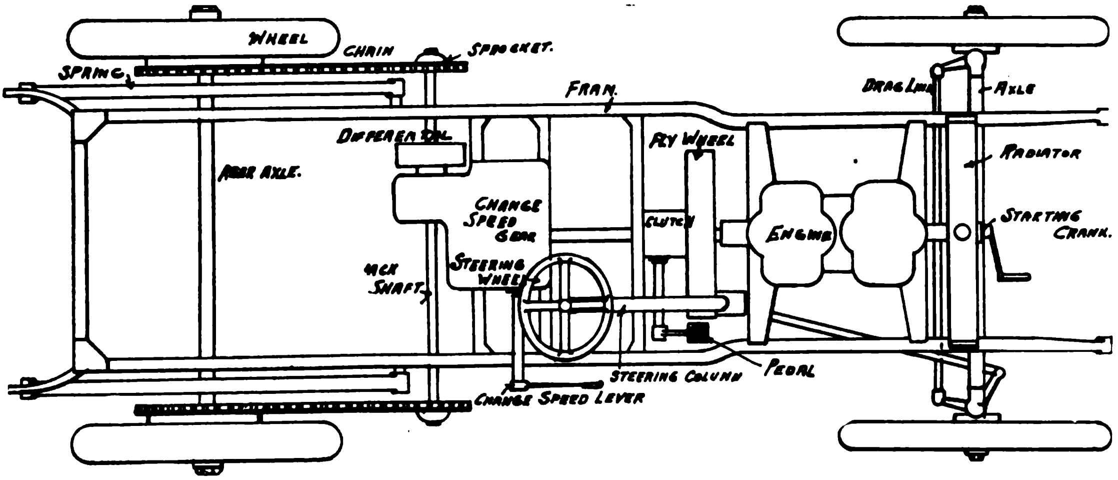


Fig. 3—Top View of a Double Chain driven car.

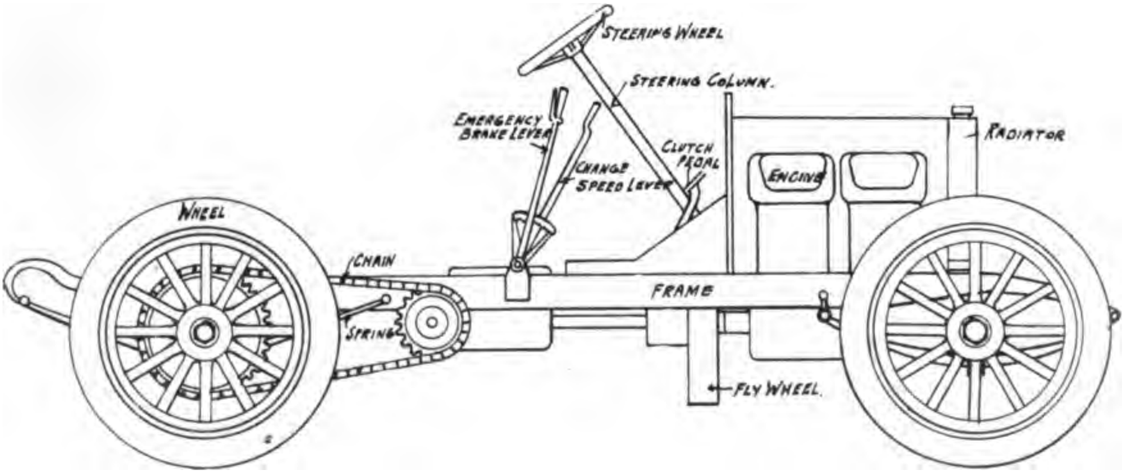
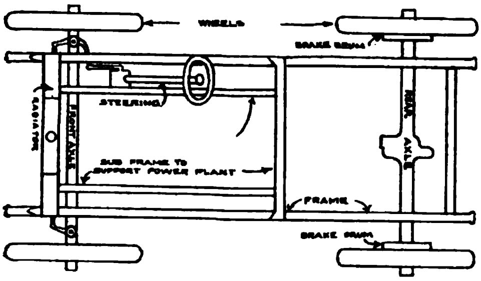


Fig. 4—Side view of a Double Chain driven car.

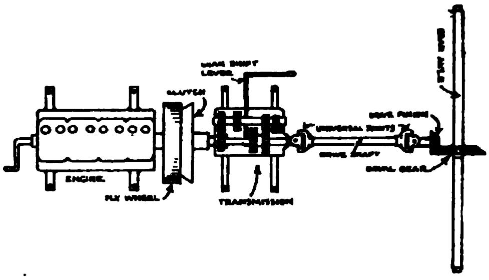
The Transmission is of the Sliding, Gear type.

NOTE—The Differential is encased with the transmission on the Jack Shaft.

CHART No. 2.



The Foundation or Running Gear.



The Power Plant and Transmission of Power.

- **FRAME**
  - MAIN FRAME
  - SUB FRAME
  - Usually made of Pressed Steel with cross members riveted.
- **AXLES**
  - FRONT
    - Tubular or
    - Solid.
  - REAR
    - Single Chain or
    - Double Chain or
    - Shaft Driven.
- **SPRINGS**
  - FULL ELLIPTIC—Usually on rear.
  - HALF ELLIPTIC
    - Usually on front—sometimes front and rear.
- **WHEELS**
  - WOOD
  - OR
  - WIRE (seldom used.)
- **TIRES**
  - PNEUMATIC
    - Single Tube (not much in use.]
    - Double Tube with Inner Tube (in general use.)
  - SOLID RUBBER—usually used on trucks
- **STEERING DEVICE**
  - WORM AND SECTOR TYPE
  - OR
  - SCREW AND NUT TYPE
- **BODY**
  - RUNABOUT
  - ROADSTER
  - TOURING CAR
  - LIMOUSINE
  - COUPE
  - DELIVERY
  - TRUCK

- **ENGINE**
  - CYCLE
    - Two Cycle Type
    - Four Cycle Type (in general use.)
  - CYLINDER
    - ONE—Horizontal or Vertical.
    - TWO—Opposed or Vertical.
    - THREE—Vertical.
    - FOUR—Vertical.
    - SIX—Vertical
  - TYPE OF CYLINDER
    - "T"-Head Type
      - Exhaust Valves on one side and Intake Valves on the other side.
    - "L"-Head Type
      - Both Valves on one side or Intake in the Head.
  - VALVES
    - Intake
      - Mechanically Operated or
      - Automatc.
    - Exhaust
      - Always Mechanically Operated.
  - CARBURETION
    - Carburetter
      - Side Float Type or
      - Center Float Type.
    - Method of Feed
      - Gravity or
      - Pressure
  - IGNITION
    - Low Tension
      - Battery or Magneto with a Low Tension Coil and a "Make and Break" system of ignition.
    - High Tension
      - Battery or Low Tension Magneto with a High Tension Coil and Jump Spark Plug or High Tension Magneto.
  - COOLING SYSTEM
    - Radiator
      - Cellular Type.
      - Tubular Type.
      - Honey Comb Type.
    - Fan
    - Circulation
      - Pump or
      - Thermo-Syphon.
- **CLUTCH**
  - CONE TYPE or
  - MULTIPLE DISC TYPE
- **TRANSMISSION**
  - SLIDING GEAR—"Progressive" Type.
  - SHIFTING GEAR—"Selective" Type.
  - PLANETARY TYPE.
- **DRIVE SYSTEM**
  - PROPELLER SHAFT
    - With Universal Joints and Drive Pinion.
  - CHAIN DRIVE
    - Single Chain. or
    - Double Chain.

NAMES OF THE PARTS OF A MOTOR CAR.

This Table gives the names of the parts necessary for the construction of a Motor Car. It is also intended to give the different styles or types of certain parts now in general use. There may be other types of parts being used by some manufacturer s but they will be mentioned in this book further on.

INSTRUCTION No. 1.

CAR COMPLETE: General Description. What each Part is for and Relation of Parts. Description of the Assembly of the Car.

The Frame of an Automobile is the foundation that supports the parts, so that they are kept in the proper relation to each other.

The Axles, with the wheels, are attached to the frame by **springs.** Details will be explained further on.

The Front Wheels Run Loose on the Axle, and guide the car.

They Are the Steering Wheels, and they are moved from side to side by means of a steering wheel, or other device, and the direction is controlled in this manner.

The Rear Wheels Are Revolved by the Engine, and drive the car.

The Springs Act as a Cushion and protect the machinery and occupants of the car.

Motor Cars Are Fitted With Brakes, for stopping or slowing down.

Tires Made of Rubber are fitted to the wheels to take up the vibrations that are too sudden for the springs to absorb.

The Motor Furnishes the Power that drives the car.

It may be located in any place on the frame; upright or lying across the front, the center, or toward the rear. See charts 1 and 2.

The Transmission is that part which transmits the power from the motor to the driving wheels through a system of **Speed Change Gears.**

A Clutch Is Placed Between the Motor and Transmission; this permits the engine to run free, or when thrown in it connects the motor to the change speed gear and drives the car. See Fig 1, Chart 1.

The Clutch Is Operated by a Foot Pedal and is thrown in or out by the driver. See Fig. 3, Chart 2.

In a Locomotive, the engine is connected direct with the wheels, so that when the engine runs the locomotive moves.

In an Automobile, the engine may be disconnected from the transmission by means of the clutch, so that the motion of the transmission or of the entire car may be stopped without stopping the engine.

When a Bicyclist Wants to Race on a Level Track he gears his wheel up high, and one revolution of the crank takes him further. Yet if he takes this wheel on the roads and encounters a hill he must get off and walk or exert an extra lot of power—he needs a wheel geared lower.

In the Same Way, when an engine is required to do more than ordinary work, the transmission or change speed gear contains from two to four changes of gears and helps out the motor by changing the gear needed.

It Allows the Car to Move at Various Speeds while the speed of the engine is unchanged.

On the First Change of Gears, the motor makes quite a number of revolutions, 15 or 20, while the wheels revolve once, which makes the auto move forward slow, but with considerable force, so that it can go up a steep hill or through sand.

The Second Change of Gears gives one revolution of the wheels to from eight to twelve revolutions of the engine, which moves the car faster than the slow or first change of gears, but with less force.

The Third Change of Gears gives one revolution of the wheels to from two to four revolutions of the engine, which gives the car high speed over good roads.

If the Car Was Going Up a Steep Grade while on the high gears, the work would be more than the engine could do, and it would stop unless one of the lower speeds were shifted in. There would be considerably more pull on the wheels.

The Change of Gears are operated by a side lever, and any change of gears can be made instantly.

The Transmission also contains a set of reverse gears, which, when thrown in, will reverse the motion of the car without reversing the motion of the engine.

The Change Speed Gear may be connected so that it drives the wheels by the following methods:

First—Chart No. 1—By a **Driving Shaft,** to the rear axle, which it revolves by means of bevel gears, the wheels and axle turning together.

Second—Chart No. 1—By a **Single Chain** to the rear axle, wheels and axle turning together.

Third—Chart No. 2—By **Two Chains,** one to each rear wheel, which run loose on the axle, like buggy wheels.

When the Axle Revolves, it is called a LIVE AXLE; when the axle is stationary, as shown on Chart No. 2, it is called a DEAD AXLE.

The Connection Between the Transmission and the Wheels is called the DRIVE SYSTEM.

When a Buggy Turns a Corner, the outside wheels revolve faster than the inside wheels, because they travel a longer distance.

The Front Wheels on an Automobile Run Loose on the axle. For this reason the outside wheel is able to revolve faster than the inside wheel when the car is turning a corner.

The Wheels in Rear must do the same thing; if they were forced to revolve at the same speed, one would slide because it could not keep pace with the other.

When They Run Loose on the Axle, they would take care of this themselves, but as both are driven by the engine, the transmission is fitted with a DIFFERENTIAL, or at times called a COMPENSATING GEAR.

This Device Is Automatic, and permits the wheels to revolve at various speeds, although both are driven by the engine.

The Automobile Frame, with all parts of the running gear, the transmission, engine and other parts of the mechanism, when it is without the body, is called the CHASSIS.

Different Types of Bodies may be attached to a chassis, and are generally fastened down with bolts.

The Frames Are Made of Pressed Steel, or wood and steel.

The Side Members of the Frame Project at Both Ends, forming HANGERS, to which the springs are attached.

The Wheel Base of an automobile is the space between the rear axles and the front axles.

The Long Wheel Base Rides Easier than a short wheel base. The frame must be sufficiently stiff, however, to prevent sagging from the weight on same.

The Wheel Bases vary on runabouts from 80 inches to large touring cars to 130 inches.

The Tread is the distance between the wheels from center to center.

The Standard Tread Is 56 Inches, measured where the wheels touch the ground, center to center.

The Treads of Wagons and Carriages Vary in Different Parts of the Country and is usually 48 inches.

Small, Light Cars are sometimes made with a smaller tread than 56 inches, but it is exceptional.

The Clearance is the distance from the lowest point of the car to the road.

For Rough Roads, a greater Clearance is required than for smooth roads, as a high place in the road would strike parts of the machinery that hung too low.

The Front Axle, which is solid and heavy, is usually curved down in the center, so that it will be the first part of the car to strike a high place, thereby protecting the delicate parts behind it.

BODIES.

The Bodies of pleasure automobiles are of four kinds: Runabouts, roadsters, touring or tonneau, limousine or enclosed bodies.

A Runabout Body has room for the driver and one passenger, and sometimes is equipped with a single seat behind and is then called a roadster.

A Touring or Tonneau Body has, in addition to the front seat for the driver and one other, seats behind for from two to five passengers, the body being open, or with a temporary top.

Limousine Bodies have a fixed, permanent roof, with windows in the sides, usually placed between the rear seats and the driver's seat.

They are used principally for driving in cities; the roofs are strong enough to carry baggage when touring, and sometimes have railings to hold it.

Commercial Vehicles are those used for business purposes such as taxicabs, delivery and trucks.

Automobiles Are Required to Carry Two Lights in front, and another, called the TAIL LIGHT, in the rear, and are usually ordinary kerosene lamps.

To make driving at night safe, there are usually head lights, which burn acetylene gas.

Acetylene Gas Is Generated by adding water to calcium carbide and the gas is supplied from a generator that makes it as it is needed.

The Generator consists of a basket to hold the carbide, and a tank from which water drips; this water in dripping on the carbide produces gas, the gas being carried to a holder and from there fed to the lamps.

The Gas Tank is also used to great extent, which consists of a steel tank charged to a high pressure of 250 to 280 pounds of gas, and when the gas runs out this tank is exchanged for another fully charged.

Acetylene Lamps are generally mounted as high as possible, to give the best illumination of the road.

They are often built like search lights, and are swung from side to side.

Speedometers Show the Speed in miles per hour, and are operated by flexible shaft driven from the front wheel.

Odometers show the number of miles traveled, either on one trip, or during the entire season.

Speedometers and Odometers are often built in one case, for the sake of compactness, one cable driving both.

The Most Usual Form of Horn for Automobiles is sounded by pressing a rubber bulb, and the tube from the bulb to the horn is long enough to have the former at the driver's seat, and the latter well forward.

Another Form of Alarm that is coming into use is blown by the pressure of the exhaust from the engine, and it is sounded by pressing on a foot pedal.

Exhaust Whistles are the name of these horns, and the sound is very much like a locomotive whistle.

Tool Boxes for tools and spare parts are either built into the body, or are strapped on the steps, which are called RUNNING BOARDS.

Mud Guards Are Always Fitted Over the Wheels, to protect the car and occupants from the mud thrown by the wheels.

The Wheels of an Automobile Are Smaller Than Those of a Carriage, because rubber tires for a large wheel would cost much more than for a small one, and there would be more danger of damage.

Automobile Wheels Must Be Very Strong, because of the weight that they must support, and the strain that they are under.

They Are Usually of Wood, with a wood felloe, over which fits a steel rim that holds the tire, but there are several forms of metal wheels, either with wire spokes, or stamped out of sheet steel.

The Modern Cars are Fitted with Steel Pans, which extend under the mechanism, protecting it from mud and dust.

The Engine, When in Front, is covered by a steel HOOD, or BONNET, which protects it from dust.

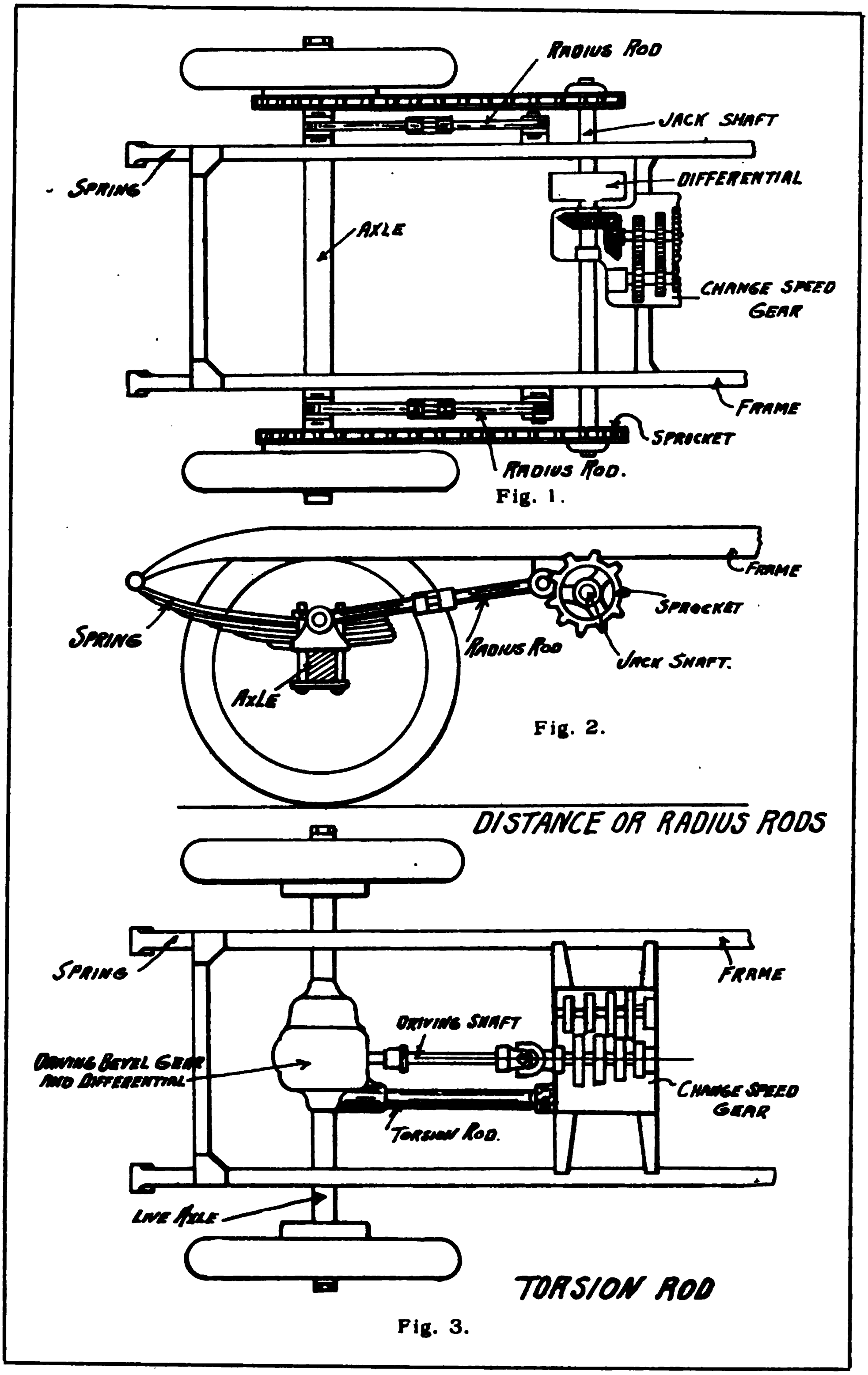


Illustration explaining the Radius Rod and Torsion Rod.

CHART No. 3.

INSTRUCTION No. 2.

DRIVES: Double Chain Drive, Single Chain Drive. Chains, Adjusting Chains. Propeller or Shaft Drive. Bevel Gears. Gear Cases. Radius Rods. Torsion Rods. Drive Reduction.

The Power Developed by the Engine and transmitted through the change speed gear is applied to the propelling of the car by those parts called the DRIVE.

There Are Three Types of Drive; one the DOUBLE CHAIN, or SIDE CHAIN drive, requiring a dead rear axle, and the other the SINGLE CHAIN drive, and the PROPELLOR SHAFT or DRIVING SHAFT drive, which require a live rear axle. (See chart 3 & 4)

DOUBLE CHAIN DRIVE.

When, As Is Usual in Cars of this Type of Drive, the engine is in front, the crank shaft is parallel to the sides of the car, and therefore at right angles to the rear axle.

The Power Developed at the Crank Shaft must therefore be turned at right angles in order to apply it to the wheels. (See fig. 1, Chart 3.)

This Is Done by Means of Bevel Gears, which are in the change speed gear case.

The Power Is Transmitted From the Crank Shaft of the Engine to the square shaft of the change speed gear by gears, as explained further on and the square shaft carries a bevel gear that meshes with another bevel gear carried on the JACK SHAFT. (See fig. 1, Chart 3.)

The Jack Shaft Passes Across the Car, running in bearings in the gear case on the frame.

It Is Held so Rigidly that while it is free to revolve, its bevel gear is always in correct relation to the bevel gear on the square shaft of the change speed gear.

The Jack Shaft Is in Two Pieces, between the inner ends of which the differential is placed the differential, of course, being inside of the bevel gear that drives the jack shaft.

At Each End of the Jack Shaft, outside of the frame, is a sprocket, which is in line with a corresponding sprocket on the rear wheel of that side. (See fig. 2, Chart 3.)

Over Each Pair of Sprockets Passes a Chain that transmits the revolutions of the jack shaft to the wheels.

The Wheels Run Loose on the ends of the dead axle.

The Chain Most Commonly Used for Automobiles is called a ROLLER CHAIN.

It Consists of Side Pieces in Pairs, each pair being secured to the adjoining pairs by rivets passing from side to side.

On These Rivets Are Steel Rollers which revolve as they touch the sprockets.

These Rollers Fit the Space Between the Teeth of the sprockets, and as the chain bends around the sprockets the rollers are stationary while the rivets turn inside of them.

To Give the Best Service, chain must run true; that is, the sprockets over which they run must be in line, the links of the chain must fit the teeth, and the sprockets must be exactly circular.

IF the Sprockets Are Out of Line, the chain will be forced to bend sideways.

If the Links Do Not Fit the teeth, there will be a grinding that will cause rapid wear, and there will be danger of the chain jumping off.

If the Sprockets Are Not Exactly Circular, during one part of the revolution the chain will be slack, and during the other part will be drawn tight, stretching it.

The Double Chain Drive has advantages that make it a favorite with many people.

A Sprocket and Chain Drive loses less power through friction than any other.

By Its Use the Weight of the Car Is Carried by a solid axle, which is lighter than a divided live axle of the same strength can be.

If a Solid Axle Is Bent, any country blacksmith can straighten it, while it requires an expert mechanic to straighten a bent live axle.

The Disadvantages of a Double Chain Drive are the difficulty of properly lubricating the chains, their rapid wear in consequence, and the liability of chains to stretch and jump off the sprockets.

SINGLE CHAIN DRIVE.

This Type of Drive is used only for cars with engines of small power, in which the engine is usually horizontal, with the crank shaft lying across the car and parallel to the rear axle.

A Planetary Change Speed Gear is usually used in a car of this type, and its sprocket is in line with the sprocket mounted on the differential on the rear axle.

These Two Sprockets are connected by a chain, similar in construction and action of a double chain drive.

This Is the Simplest Form of Drive, and is occasionally used for light delivery wagons as well as for runabouts and small tonneau cars.

Examples of This Type of Drive may be seen in Fig. 2, Chart 1.

CHAINS.

If Chains Could Be Protected From Dust, and be run in an oil bath, their use would be universal, but no method of doing this has yet been devised.

A Case or Housing Cannot Be Fitted Around the Chain, because the construction would also require it to contain the brakes as well as the sprocket, and to surround the axle.

Good Refined Tallow Gives a Chain the Best Protection against dust and grit.

The Tallow Should Be Melted in a Broad Shallow Pan, heating it only enough to make it liquid, and the chain after being thoroughly cleaned, should be laid in it.

Every Joint should be worked so that the tallow will enter all of the crevices, and when this has been done the chain should be hung up by one end to dry, the surplus tallow dripping into the pan.

When it Cools, the tallow hardens, and that on the surface may be wiped off.

The Grease Thus Fills Every Joint of the Chain, and lubricates it as well as keeps out the grit.

This Will Protect the Chain for from one to two thousand miles of running of the car.

When Inspection shows it to be necessary the chain should be removed from the car and soaked in kerosene, working the joints to remove the grit.

After it Is Thoroughly Dried, it should be re-tallowed.

When the Teeth of the Sprockets show signs of wear, they may be reversed; reversing them will bring the wear on the opposite sides of the teeth.

A New Chain Will Always Stretch, and for this reason must be watched in order to keep it in adjustment.

When the Chain Has Stretched Sufficiently to permit it, one link should be removed, and the adjustment shortened to bring the distance between the sprockets to what it was originally.

It Is Well to Carry an Extra Chain Complete and ready to attach in case of breakage, or in any case, extra links, called MASTER LINKS, that may be used to make repairs.

The Rivets of the Broken Link may be cut out with a small cold chisel, and the new link applied, being held in place by a screw and nut instead of being riveted.

ADJUSTING CHAINS.

In a Single Chain Drive, the chain should have a little slack, but not enough to permit it to show any signs of climbing off the teeth of the sprockets.

Over a Smooth Road, the chain may be slack without damage, but over a rough road, the jolts will throw the chain, and it will climb off if it can.

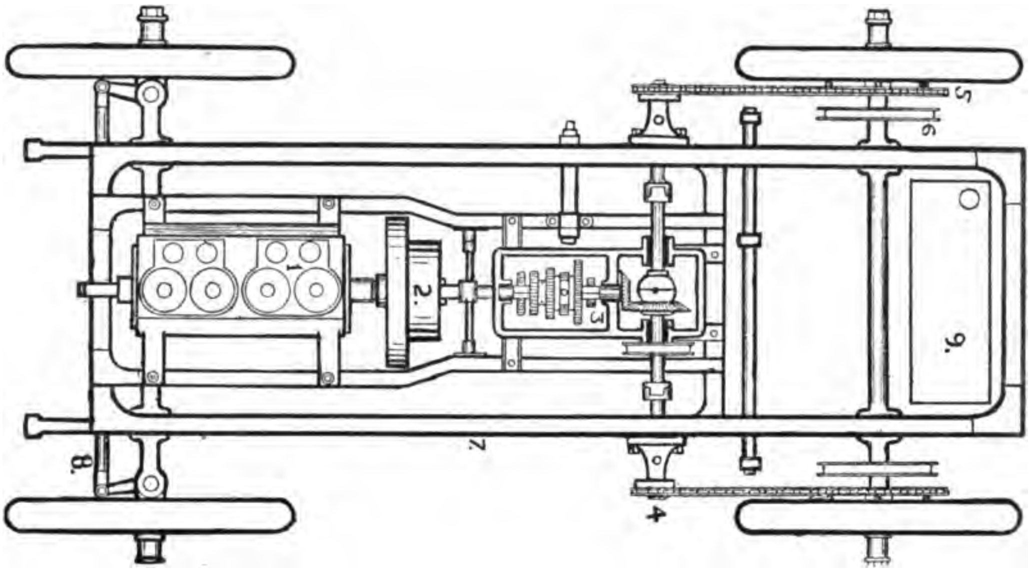
With the Rear Wheels jacked up, the chain should be operated, and should not be tight at any time.

It Frequently Happens that sprockets do not run true, and in such a case the chain will not have the same tension at all times.

If Much Out of True, the chain will be so slack at the loose point that it will be dangerous, and repairs or adjustments should be made to correct it.

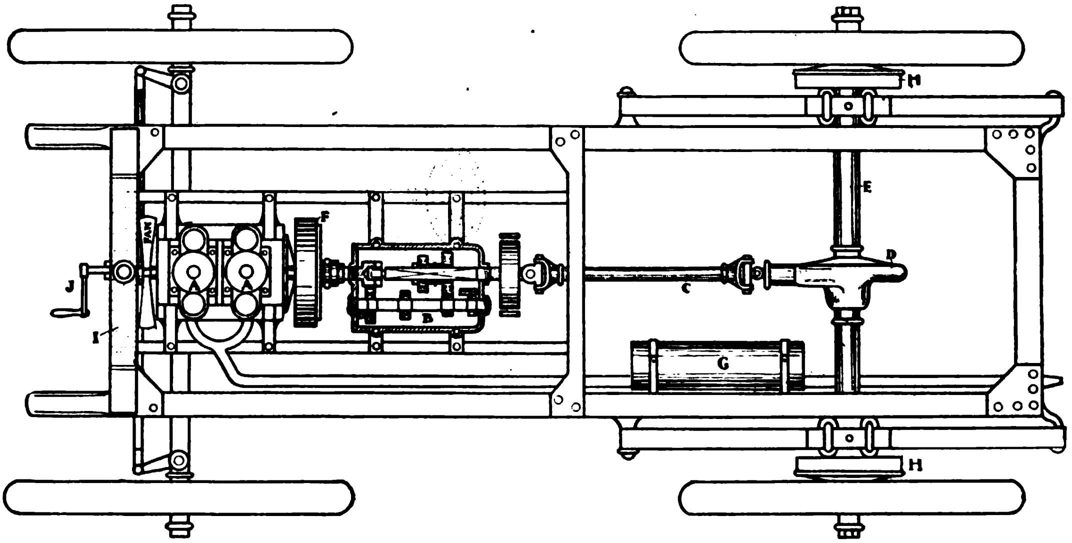
This Unevenness May Be Due to a sprung axle or crank shaft.

In Adjusting the Chains of a Double Chain Car, it is most important to have the two chains equally slack, for with one tight and the other loose, there will be a tendency to spring the parts.



"Chassis" of Car fitted with Differential on Countershaft and Driving by Chains.

(1) Four-cylinder motor. (2) Disc clutch. (3) Change gears and differential countershaft. (4) Driving axle and chain sprockets. (5) Chain wheels. (6) Brake drum. (7) Frame work of channel steel. (8) Steering rod connecting steering axles. (9) Gasoline tank.



Chassis of Car having a Propeller Shaft and Gear Drive.

(AA) Two-cylinder motor. (B) Gear box. (C) Propeller shaft. (D) Differential and bevel drive. (E) Live axle. (F) Clutch. (G) Muffler. (H) Brake drums. (I) Radiator. (J) Starting handle.

CHART No. 4.

They Should Be Loose enough to run easily, without being either so loose as to climb, or so tight that they bind.

PROPELLER DRIVE

In This Type, the square shaft of the change speed gear is extended to the rear axle, where it ends with a bevel gear. (See Fig. 3, Chart 3 & 4.)

This Bevel Gear Meshes with another bevel gear on the differential that is mounted between the inner ends of the two parts of the live rear axle.

The Extension of the Square Shaft, which is called the propellor or driving shaft, always has one, and often two, universal joints in it, so that the moving of the rear end as the axle receives the jolts of a rough road does not effect its driving.

The Bevel Gears Are Contained Within a Casing or housing that supports the bearings for the parts of the axle, and also the end of the driving shaft, so that the bevels are held in the same relation to each other, regardless of the moving of the axle.

The Advantages of This Type of Drive are that all of the moving parts are enclosed and protected from dust, and run in grease or oil, which means perfect lubrication.

The Disadvantages are the necessity for having a divided rear axle, the difficulty of keeping the bevel gears in exactly the correct relation to each other, because of the bending or SPRINGING of the axle, and the troubles that may come from the general weaknesses of a live axle. (See Dyke's working model of the Differential.)

BEVEL GEARS.

Bevel Gears must be cut more accurately, and meshed more carefully, than spur gears.

To Transmit Power without more loss by friction than can be helped, there must be as little play as possible without having the teeth bind.

The Setting of Bevel Gears can best be done by an expert, for if incorrectly meshed they will be noisy, and will wear rapidly.

GEAR CASES.

Transmission Gear Cases are usually made of aluminum, that metal being light and sufficiently strong.

Those Parts of a gear case that support bearing are reinforced and sometimes made in two parts that supporting the bearing being of bronze, the aluminum covers being bolted on.

As a Gear Case Always Contains Oil or grease, it is fitted with a small cock or a hole and plug at its lowest point.

Opening the Cock, or removing the plug, permits the case to be drained and washed out.

RADIUS RODS.

Radius Rods, see Fig. 2, Chart 3, are used to keep the driving axle at right angles to the frame of the car, and to the drive.

On Side Chain Cars, they extend from a point close to the jack shaft to the rear axle, so that no matter how the axle may move on a rough road, the distance between the sprockets is kept about the same. (Fig. 2, Chart 3.)

On Shaft Driven Cars, the rods extend from a point a little to the rear of the center of the frame to the rear axle.

If It Were Not for Radius Rods, a wheel that struck a stone or other obstruction would be driven back, so that the axle would be twisted, throwing the drive out of line.

The Spring on the Side Struck, would give, and in time the whole axle would be to the rear of its correct position.

Radius Rods are Adjustable; turnbuckles permit them to be shortened or lengthened.

On Chain Driven Cars, the radius rods also serve to adjust the chains; shortening the rod loosens the chain, and lengthening the rod tightens it.

TORSION ROD.

A Torsion Rod, (''torsion'' means a twist) is used on shaft driven cars in addition to radius rods, and it extends from the change speed gear case to the bevel gear case on the rear axle.

A Usual Construction has a ball and socket joint as its forward end, the rod being heavy and stiff. (See Fig. 3, Chart 3.)

If It Were not for the Torsion Rod, the revolving of the bevel gears would tend to revolve the rear axle housing around the axle, instead of revolving the axle inside of the housing.

While the Construction of the Rear Axle would of course prevent this, there would be considerable play in the course of time, and the driving shaft might be strained and sprung out of line.

The Torsion Rod receives this strain, and protects the driving shaft.

DRIVE REDUCTION.

In all But Racing Cars, the speed of the crank shaft is reduced so that the axle wheels turn once while the crank shaft revolves from two to four times with the high speed gear engaged.

On Cars with Single Chain Drive, this is done by having the change speed gear sprocket smaller than the axle sprocket.

If the Reduction Is to Be Three to One, that is, if the crank shaft revolves three times to once of the axle, the axle sprocket will have three times the number of teeth that the change speed gear sprocket has.

On Shaft Driven Cars, the reduction is made at the bevel gears.

The Bevel on the Axle is given as many more teeth than the pinion on the driving shaft as is necessary for the reduction that is required.

The Reduction on Side Chain Cars is sometimes made at the bevel driving the jack, but usually at the sprockets.

Racing Cars, or high powered touring cars for use over good roads, apply this reduction for the direct drive, but by the use of gears in the change speed gear case may bring the speed of the wheels to the speed of the crank shaft, or even more.

When the ''Gear Ratio'' of a Car Is Spoken of, it is this reduction that is meant.

A Car Spoken of as Having a ''Gear Ratio of 3½'' is one in which the crank shaft makes 3½ revolutions to one revolution of the wheels on the high gear.

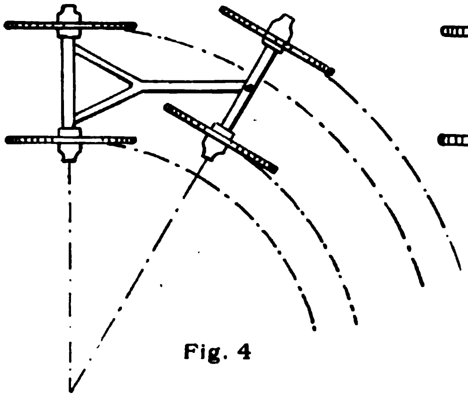


Fig. 4

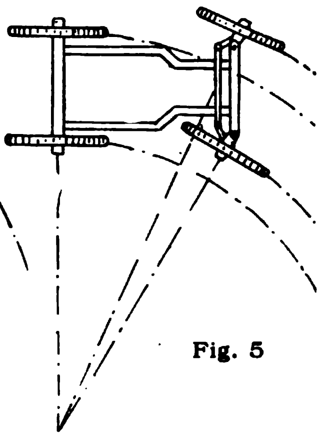


Fig. 5

Illustrating the difference in position of the front axle on a horsedrawn vehicle (4) and the front axle of an automobile (5) in turning a curve.

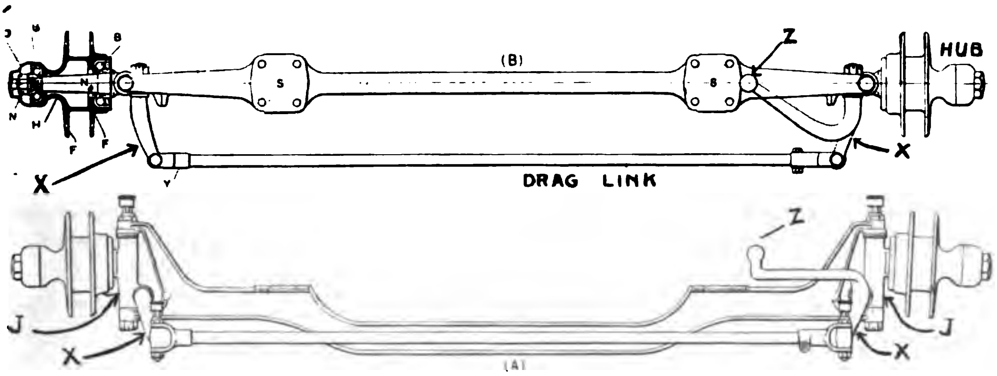


Fig. 6—Top and side view of a Front Axle and Steering Knuckle and Connections.

A-B—Axle proper.
J—Steering Knuckle.
X—Steering Knuckle Arms.
B—Ball Bearings.
Z—Rod from Steering Wheel connects here, (see C fig. 2, Chart No. 7.)

CHART No. 5.

INSTRUCTION No. 3.

STEERING, SPRINGS, BRAKES.—The Principle of Steering the Front Wheels. The Irreversible Steering Gear. Springs. Single and Double Acting Brakes.

Pulling on One of the Reins Swings the Horse to that side in steering a wagon.

The Shaft or Pole Is Attached to the Axle, and the axle is pivoted to the king pin, all swing with the horse.

If You Go Straight Ahead, the front and rear wheels of any vehicle move in straight lines.

To Make a Turn to One Side or the Other, the front wheels are swung so that they are at an angle with the rear wheels.

Whenever the Front Wheels Stand at an Angle with the Rear Wheels, the vehicle will turn, and it will continue to turn until the front wheels are swung back to a straight line again.

In a Horse Drawn Vehicle, the front wheels are square with the axle, for wheels and axle swing together.
(See Fig. 4, Chart 5.)

In an Automobile, the front axle does not swing, but each wheel swings on a pivot at the end of the axle.

It Would Not Be Practical to Steer an Automobile as a Horse Drawn Vehicle Is Steered, for the axle would have to be very heavy to support the weight, and beside, it would be so hard to swing it that steering would be difficult.

A Fixed Front Axle is always used on automobiles.

The Pivots on which the front wheels swing must be as close to the hubs of the wheels as possible, for the closer they are the less leverage there will be to overcome, and the easier it will be to steer.

When a Wagon or Automobile Turns a Corner, it moves on the arc of a circle.

If the Circle Were to Be drawn Out on the Ground, the location of the center would depend on the shortness of the curve.

In a Horse Drawn Vehicle, the front axle, because it swings on the king pin, ALWAYS POINTS TO THE CENTER OF THE CIRCLE. (See Fig. 4, Chart 5.)

Notice That Both Wheels and the Axle Are Perpendicular to the Same Radius of the circle in Fig. 4.

The Front Axle of an Automobile Is Fixed and Cannot Turn, and therefore ONLY ITS PIVOTED ENDS POINT TO THE CENTER OF THE CIRCLE. Chart 5, Fig. 5.

Notice That the Axle Does Not Move but that each wheel does.—Fig. 5.

When Running Straight Ahead, the front wheels of an automobile are square with the axle.

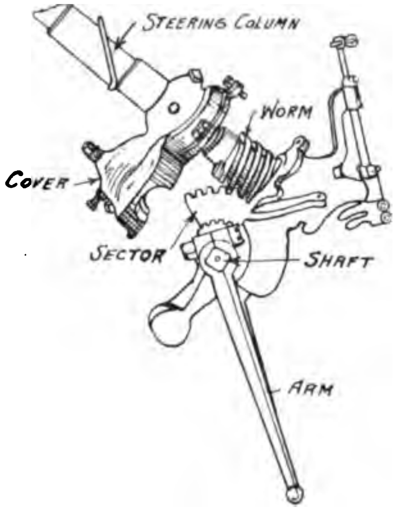


Fig. 1 Worm and Sector Steering Gear.

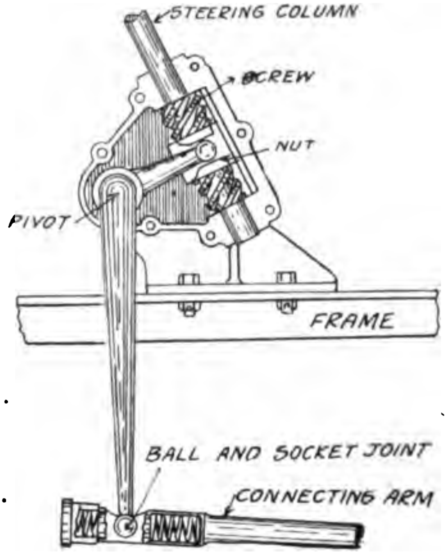


Fig. 2—Nut and Screw Steering Gear.

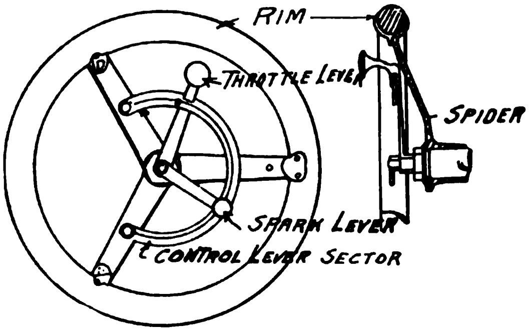


Fig. 3—The Steering Wheel showing spark and throttle levers.

(Wheel is placed on top of the steering post (A fig. 2 Chart 7.)

CHART No. 6.

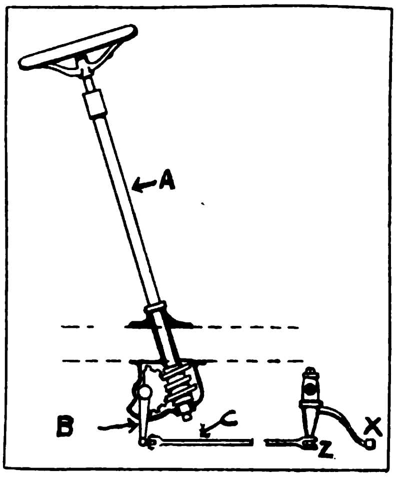


Fig 2.

A—Steering post or steering column.

B—Steering gear arm.

C—Steering rod or connecting arm.

Z—Steering knucele arm.

X—Rod connecting with Drag Link (see fig. 6, Chart 5.)

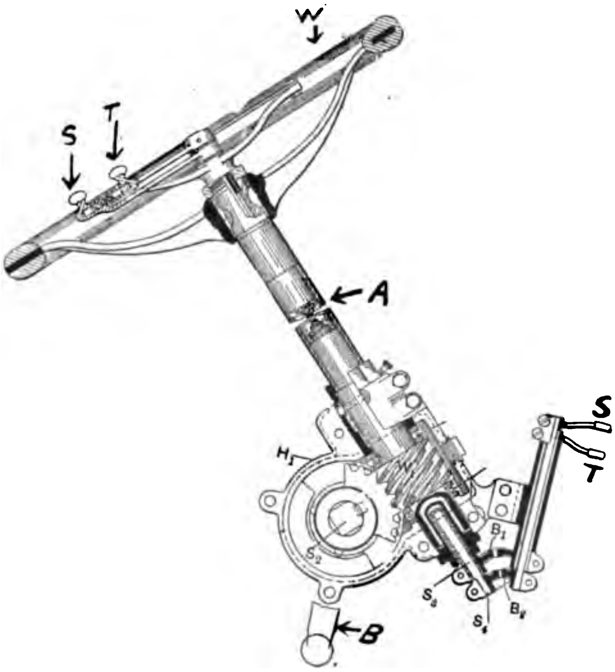


Fig. 3—Showing Steering Device Complete.

A—Steering post. B—Steering arm. W—Steering wheel. S—Spark lever connects with rod S3 (which runs through the hollow steering post) and operates through bevel gears B1 the bell crank S, which in turn operates the timer on the engine.

T—Throttle lever connects with S4 rod through bevel gears B2 and operates the bell crank T, which in turn is connected by a rod with the throttle valve on the carburettor.

Explanation of the Steering Gear and its Parts and Connections.

CHART No. 7.

When Turning, the front wheels are not square with the axle, but at an angle with it.

Because Each Wheel Is Square with its Axle End, and both axle ends point to the center of the Circle, each wheel is square, or perpendicular to, a radius of the circle.

If Both Were Perpendicular to the Same Radius, WHICH THEY ARE NOT, the wheels would be parallel with each other.

Thus While the Front Wheels of a horse drawn vehicle are always parallel to each other, the front wheels of an automobile turning a corner ARE NOT PARALLEL TO EACH OTHER.

The Steering Mechanism Must Be so Arranged that the front wheels are parallel when the car is running straight ahead, but stand at an angle with each other when turning a corner.

Each of the Pivoted Axle Ends, which are called STEERING KNUCKLES, has a STEERING ARM projecting from it, pointing backward or forward, NOT up or down. (See "X" Fig 6, Chart 5.)

The Ends of These Two Arms Are Connected by a rod called a DRAG LINK.

When the Drag Link Is Moved Endways, both wheels move with it.

The Two Steering Arms are not parallel, but incline a little toward each other.

If They Were Parallel, the two wheels would be parallel, no matter how the drag link was moved.

As They Are Not Parallel, moving the drag link moves one of the wheels through a greater angle than the other, depending on the direction the drag link is moved.

The Old Style of Steering Arrangement was a Lever and Rod running from the driver's seat to the steering knuckle. This old style arrangement would reverse and was unreliable.

In Striking Stones or Ruts in the Road the Wheels Could Be Thrown From Side to Side, and the driver would be obliged to grasp the steering wheel or lever firmly to keep the car straight.

A Bad Place in the Road might throw the handle or wheel out of his hand.

While This IS Good Enough for a Light Runabout, it would be very serious with a large, heavy automobile.

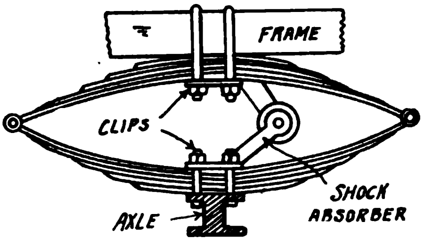
A Device Must Be Used That Will Swing the Front Wheels when the steering wheel is turned, but that will keep the front wheels steady, and prevent their moving the steering wheel.

This Is Called an Irreversible Steering Gear, and while it is made in many ways, the chief types are the WORM-AND-WORM-WHEEL, and the SCREW-AND-NUT, both shown on Chart 6, Fig. 1 and 2.

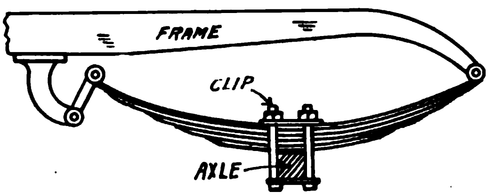
The Worm-And-Worm-Wheel Type consists of a worm, which is attached to the lower end of the rod moved by the steering wheel.

Meshing With the Worm IS a Worm Wheel, so that turning the steering wheel turns the worm, and moves the worm wheel.

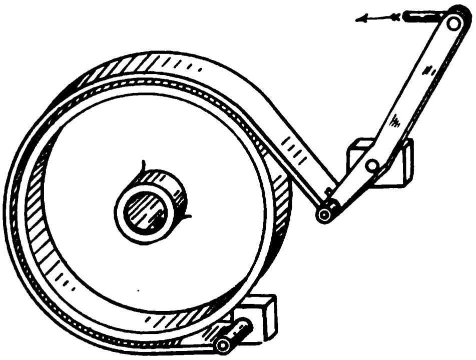
Attached to the Worm Wheel Is the Worm Wheel Arm, or steering arm, which is connected to the drag link by the connecting rod.



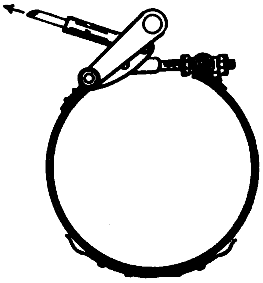
FULL ELLIPTIC SPRING



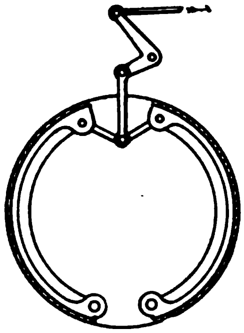
HALF ELLIPTIC SPRING-FRONT



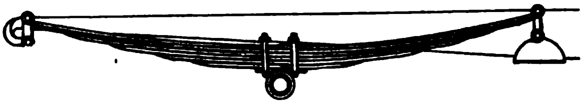
SINGLE ACTING BAND BRAKE



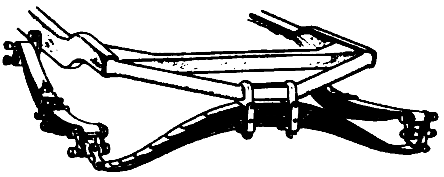
DOUBLE ACTING BAND BRAKE



INTERNAL EXPANDING BRAKE



HALF ELLIPTIC SPRING-REAR.



Three Half Elliptic Springs, now a popular form of rear suspension.

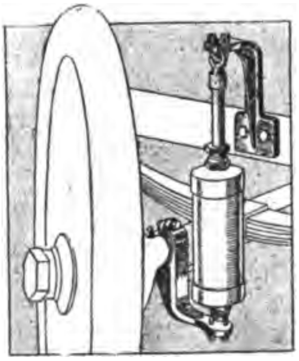


Fig. 7—Plunger Type of Shock Absorber.

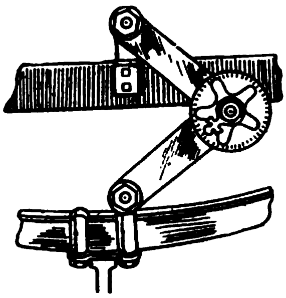


Fig. 8—Friction Type of Shock Absorber.

CHART No. 8.

The Connecting Rod End of the Worm Wheel Arm is ball shaped, and fits in a socket, so that the fit is always tight, whatever the angle between the arm and the connecting rod may be.

The Socket Is Often Movable, with strong springs on each side to hold the parts together, and to take up some of the shocks of the road.

The Worm and Worm Wheel are contained inside a metal case to protect them from dust, and to hold the grease in which they are packed.

The Screw-and-Nut Steering Gear shown in the chart has a nut through which a screw passes, instead of a worm wheel.

Turning the Screw, which is a long worm, moves the nut up or down.

One Arm of a Lever Fits in a Groove on the Outside of the Nut, and the other end is connected to the drag link by a connecting rod.

Steering Gears are usually built so that wear can be taken up, for looseness of the parts might make the steering uncertain.

The Breaking of Any Part of the Steering Connections is more likely to cause a wreck than the breaking of any other part of the car, and must be watched carefully.

The Parts Must Be Kept Tight Enough to Prevent Play, but must not be so tight as to make steering hard.

All Parts Must be Kept Lubricated, and the connecting rod, drag link, and knuckle joints are usually packed in grease and protected from dust by leather pockets that buckle over them.

SPRINGS.

All Vehicles intended to move at more than a very slow speed must be provided with springs.

Springs Not Only Protect the occupants from the vibrations of a rough road, but also keep the machinery from being shaken to pieces.

The Size and Strength of the Springs depends on the weight of the vehicle.

Springs That Are Too Weak will not give sufficient protection and if they are too strong they will not have enough elasticity.

The Most Usual Form of Springs for light vehicles is the FULL ELLIPTIC. Chart 8.

The form in most general use for heavy automobiles is the HALF ELLIPTIC, which corresponds to the lower half of a full elliptic spring

An Elliptic or Half Elliptic Spring Is Built Up of a Number of Plates, or LEAVES, of different lengths.

The Best Form for the Leaves Is Broad and Thin, rather than thick and narrow, and they must be made of good steel.

The Longer Leaves Rest on the Shorter, so that when the spring is compressed the weight is supported by all of them.

When the Spring Is Compressed, each leaf is flattened out by the longer leaf that rests on it.

The Leaves Are Held Together at the center of their lengths by CLIPS, and the ends of the leaves slide on the leaves that they support.

When the Wheel Drops Into a Hole in the Road, the support of the body is removed, and it drops, compressing the springs.

After Being Compressed, the springs expand and throw the body upward, and the wheel rolling out of the hole also moves up.

As the Top Half of the Spring Moves Downward by the Compression, the bottom half is being moved upward by the wheel as it rolls out of the hole.

This Action Makes the Up-and-Down Movement of the body much less than the up-and-down movement of the wheel.

When It Strikes a Stone, the wheel is thrown upward, compressing the spring.

While the Upward Motion of the Spring Is Passing to the Body, the wheel drops from the stone, and thus a large up-and-down movement of the wheel will have little effect on the body.

Thus the Springs in Being Compressed and Expanded by the action of the wheels take up most of the vibration, and the body is kept steady.

Breakage of a Spring means breakage of one or more of the leaves.

Breakage Almost Always Occurs in the expansion that follows a heavy compression, and not during the compression.

In other words, **It Is the Rebound That Breaks Springs.**

Because the Leaves Slide on Each Other, they will wear and squeak if not properly lubricated.

To Lubricate Between the Leaves it is necessary to relieve them of the weight they carry.

This May Be Done by Jacking up the Body, or taking the springs apart, and spreading heavy grease or graphite on the leaves.

The Expansion of a Spring is about equal to the compression that causes it.

In other words, the greater the downward motion of the body, the greater will be the rebound.

SHOCK ABSORBERS.

As Breakage Will Come During a Rebound, devices called SHOCK or JOLT ABSORBERS are attached to the springs to check their movement.

The Springs must be permitted to have their full compression, but the rebound, or upward movement of the body, must be prevented from being too great.

One Type of Shock Absorber may be compared to a door-check, which closes a door slowly, instead of permitting it to slam.

There Is no Resistance when the door is being opened, but great resistance when it is closing.

In This Type (Fig. 7, Chart 8), a cylinder with a plunger is placed between the axle and the body, the cylinder being attached to one end and the plunger to the other, so that when the body moves up or down the plunger slides in the cylinder.

The Cylinder Is Closed at Both Ends, and filled with glycerine or heavy oil.

When the Springs Compress and the Plunger Moves, the oil flows from the lower to the upper side through holes in the plunger.

When the Springs Expand on the Rebound, the plunger is moved in the opposite direction, and a leather washer then covers most of the holes, so that the oil can flow only slowly back to the under side of the plunger.

This Forces the Plunger to Move Slowly, and as it is attached to the body, that also is forced to move slowly.

Consequently the Cylinder and Plunger permit the body to move fast in one direction, but force it to move slowly in the other, preventing a quick jerk that would be likely to break the springs.

Another Type (Fig. 8, Chart 8.) of Shock Absorber makes use of a leather washer squeezed between two metal plates.

An Arm From One Plate Is Attached to the axle, and an arm from the other plate is attached to the body.

One Arm Is Attached to its Plate by a ratchet.

By Means of the Ratchet, the arm may revolve loosely around its plate in one direction, but when moving in the other the ratchet holds the plate to the arm, so that the plate is forced to move with the arm.

The Heavy Friction of the Leather Washer makes it difficult for the plates to slip against each other.

When the Springs of the Car Compress, the ratchet permits the two arms to come together, as the handles of a pair of scissors come together when closing.

On the Rebound, the ratchet binds, and the upward movement of the body forces the two plates to slide around, and as the resistance of the washer forces them to move slowly, the body will not jerk upward.

BRAKES.

An Automobile Is Equipped with Brakes so that its motion may be checked or stopped, or so that it may be held on the side of a hill.

In a Horse Drawn Vehicle with Steel Tires, the brake shoes press directly on the tires, but as this would quickly ruin rubber tires, brakes for automobiles are of other types.

Because of the Weight of an Automobile, its brakes must be powerful in order that it may be stopped suddenly when necessary.

Practically all Automobiles Are Fitted with Two Sets of Brakes, called the RUNNING BRAKE and the EMERGENCY BRAKE.

The Running Brake Is Applied by Pressing on a Foot Pedal, and is the one most in use because of its convenience.

The Emergency Brake Is Usually Applied by a Lever at the Side of the Driver's Seat, so placed that he may apply his whole force to it.

The Brakes Act on Drums, which may be attached to the spokes of the rear wheels, to the shaft of the change speed gear, or to the differential.

The Brake Shoe Is a Band that may either be drawn around the outside of the drum, or expanded within it so that it bears against the inside wall of the drum.

The Former Is Called a Band Brake, and is a flexible steel band encircling the drum with leather, wood fibre, blocks of brass, or other suitable material.

Band Brakes Are of Two Kinds; SINGLE ACTING and DOUBLE ACTING, the latter being an improvement on the former.

In A Single Acting Band Brake, the end of the band is attached to the frame of the car, and the other connected to the pedal or lever, so that it may be tightened around the drum to stop its revolution.(Chart 8.)

The Single Acting Band Brake (Chart 8) only binds when the drum is revolving in one direction, having very little grip when the drum is revolving in the same direction in which the band is being pulled.

This form is going out of use for automobiles, for it cannot be depended on to hold the car from running down hill backward.

The Double Acting Band Brake (Chart 8) is taking its place, for it holds with the drum revolving in either direction.

In this form, both ends of the brake are attached to the lever or pedal, and so arranged that while one end is being pulled in one direction, the other end is being pulled in the opposite direction.

This binds on the drum so tightly that it may be depended on to hold the car in any position.

The Running Brake is usually of the double acting type.

The Internal Expanding Brake (Chart 8) acts on the inside of a drum attached to the spokes of the rear wheel, and one drum is frequently used for both an internal expanding and band brake.

The Internal Expanding Brake consists of two SHOES of metal, usually brass or bronze, so formed that they fit the curve of the inside of the drum.

They Are Pivoted Together at Their Ends, so that they may be opened to press against the inside of the drum, or closed so that they do not touch it.

The Free Ends of the Shoe are connected to the pedal or lever through a TOGGLE JOINT, by means of which the shoe may be expanded with great force to bind against the inside of the drum.

CARE OF BRAKES.

As the Safety of a Car depends on its brakes they must be kept in the best possible condition.

They Should Bind Tightly when pressure is applied to them, and be free and clear when the pedal or lever is released.

A Brake Band or Shoe That Binds when the pressure is released produces friction, and makes the car hard running.

To Adjust the Brakes, jack the rear wheels clear of the ground and turn them by hand, first one and then the other.

With the Brake Lever or Pedal Released, the brakes should be free from the drums, and present no resistance to the turning of the wheels.

If the Brakes Are Clear in This Position, throw the lever or pedal on hard, and again try to turn the wheels.

If the Adjustment Is Correct, it should be impossible to move them.

Adjustments Are Usually Made by means of a TURN-BUCKLE, by which the rod connecting the band or shoe to the lever or pedal may be shortened or lengthened.

If the Brake is of the type that acts on drums on both rear wheels, both sides must bind with equal force when the pressure is applied.

To Test This, give the lever a little pressure, and then turn by hand first one wheel and then the other.

Any Difference in the grip of the brakes may easily be judged and adjustment should be made until they pull alike.

In Many Cars the rod from the lever is provided with an EQUALIZER, that keeps an equal pull on both sides.

After a Little Experience, pushing the car across a smooth floor makes a good test of the adjustment of the brakes.

Slipping of Brakes IS caused by Poor Adjustment, oil between the surfaces, or worn linings.

The first may be cured by readjustment.

In the second case, wash out the oil with a little gasoline, and if the lining is of leather, treat it with castor oil, or neat's foot oil.

Slipping Caused by Worn Linings may be remedied to some extent by taking up the turnbuckle, but if too much worn for this they must be replaced.

Replacing the Worn Lining is not difficult, as the leather or fibre is held to the steel band by copper rivets, which must be cut away and replaced with others to hold the new lining.

Because the Application of the Brake Generates Heat, leather linings will be burned if kept in contact too long.

For This Reason, Emergency Brakes, which hold the car on long hills, are lined with fibre if the brass or bronze shoe does not come directly in contact with the drum.

Where Metal to Metal Brakes Were Used a constant and extravagant supply of oil was required to prevent excessive wear. The inconvenience and uncertainty of lubrication together with the cost of renewing the expensive brake shoes rendered this type of brake unsatisfactory.

The Ideal Brake Lining then is one in which the co-efficient of friction is maximum and the deterioration due to heat is minimum. And Asbestos is the only material to-day of which such a brake lining can be made.

Asbestos Is a Fibrous Mineral; a natural rock heat-proof and practically wear-proof.

LUBRICATION OF BRAKES.

While asbestos lining requires practically no lubrication on account of its high resistance to heat, it is advisable to apply a few drops of thin oil to the brake shoes or bands occasionally, or about every 200 miles. This maintains a smooth surface on the brake drum.

See that hinges, cams, toggles and lever bearings are kept well supplied with oil. If an external contracting brake should clatter, apply three or four drops of oil to the friction surfaces.

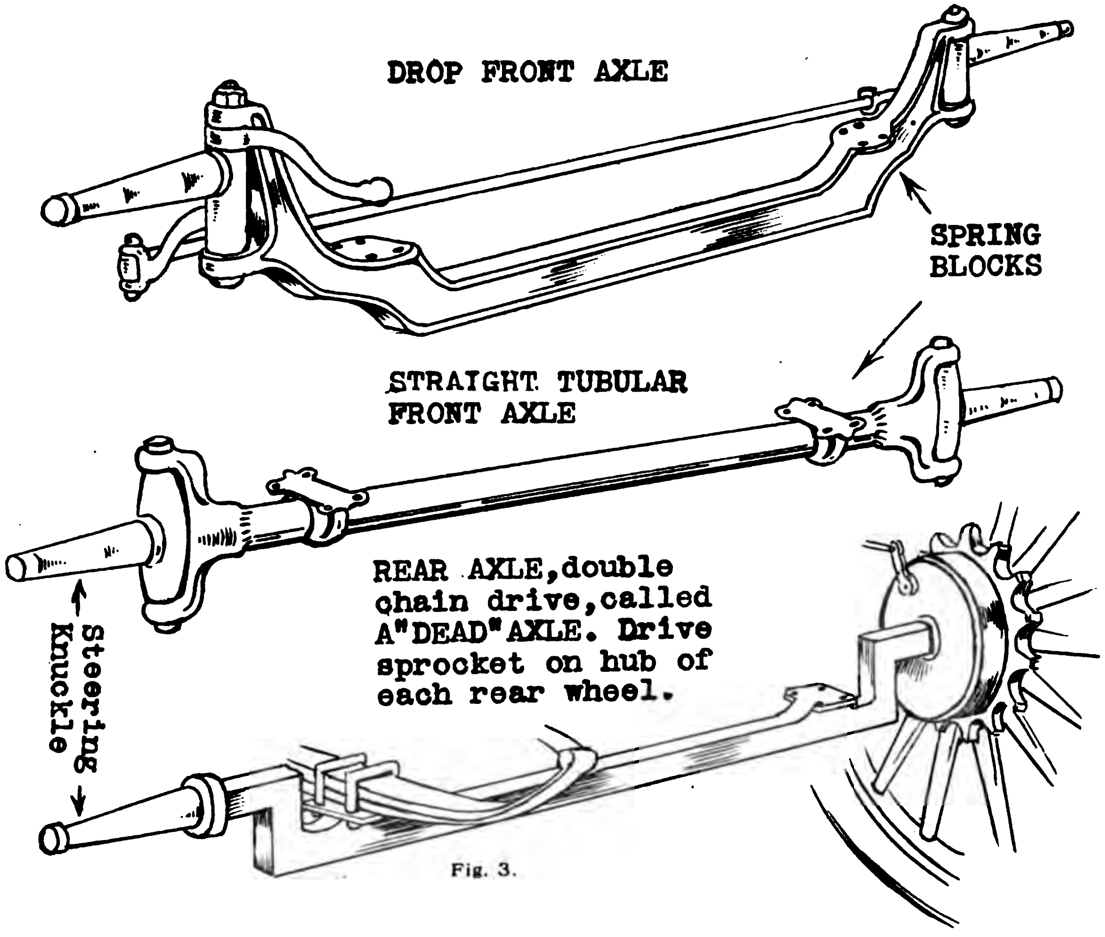
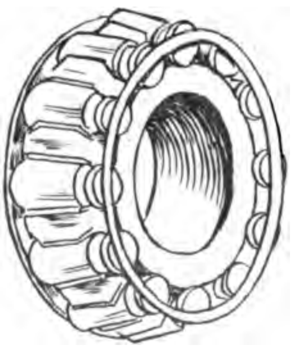
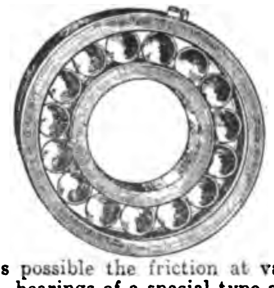

DROP FRONT AXLE
SPRING BLOCKS
STRAIGHT TUBULAR FRONT AXLE
REAR AXLE, double chain drive, called A "DEAD" AXLE. Drive sprocket on hub of each rear wheel.
Steering Knuckle

Fig. 3.



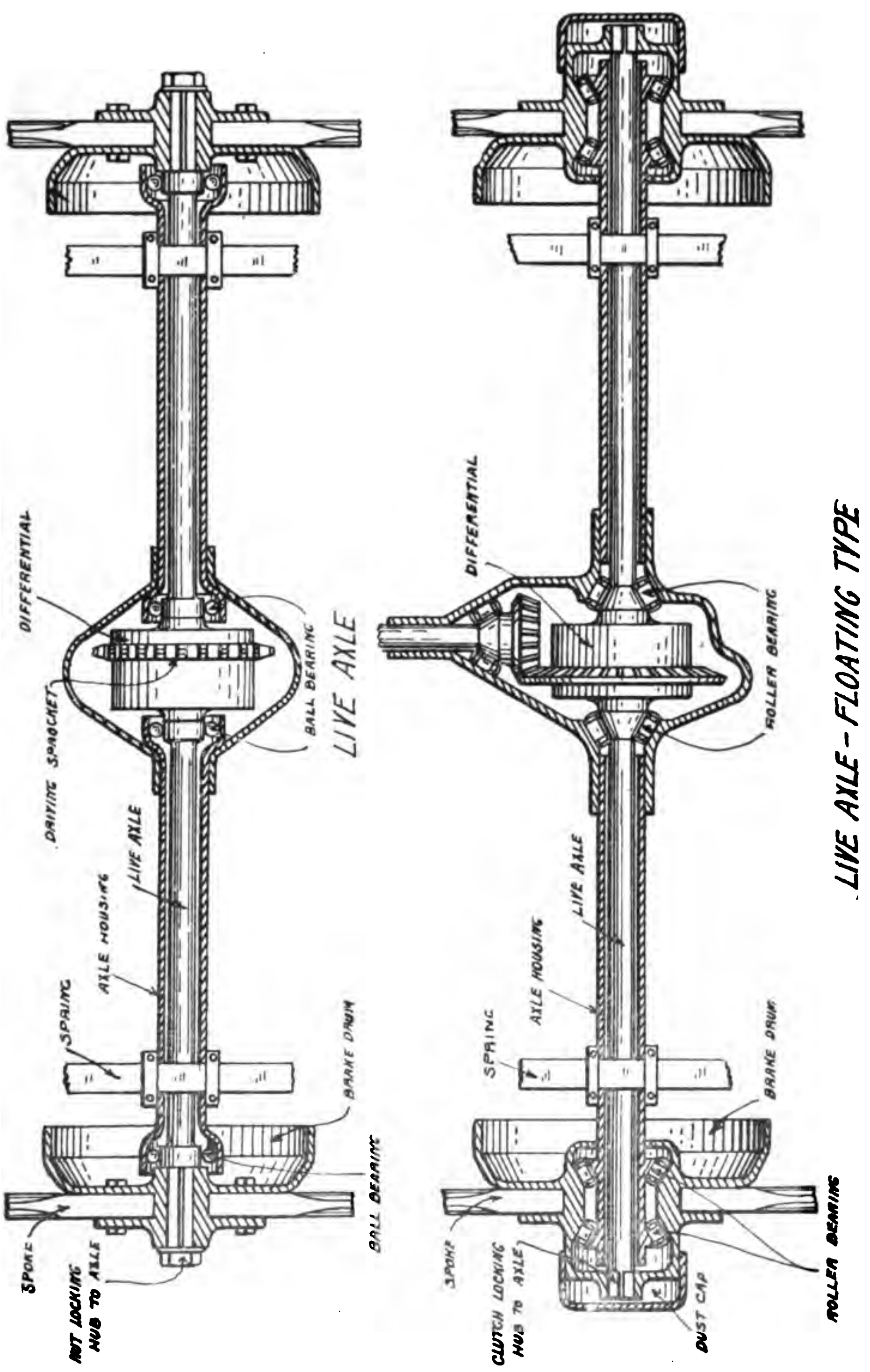
ROLLER BEARINGS



BALL BEARINGS

To reduce as much as possible the friction at various parts of the transmission system, bearings of a special type are largely adopted. These are now fitted to shaft bearings, wheels, and to some extent are being adopted for the main shaft and connecting rod bearings of engine.

CHART No. 9.



Rear Axles.

CHART No. 10.

INSTRUCTION No. 4.

AXLES AND DIFFERENTIAL OR COMPENSATING GEAR.—

Rear Axles. Live Axles. Floating Type of Axle. The Differential. The Principle, Application of the Principle. The Bevel Gear Differential. The Spur Gear Differential. Bearings; Ball and Roller.

The Front Axle of a Modern Car carries the weight of the engine, and must at the same time withstand the shocks and jars that it receives through the steering wheels; it must therefore be strong and stiff.

Formerly Axles Were Made of Heavy Steel Tubes, but steel drop forgings, or a metal known as manganese-bronze, made with a cross-section of the form of the letter H, is considered to give better results.

The Center of the Axle Is Usually Bent Down, so that it is the lowest point of the car except the wheels this is done in order to protect the mechanism from being struck by high spots in the road. (See Chart 9.)

A Rock or Stump Standing up High Enough to Hit the Fly Wheel will first strike the axle, which is strong enough to withstand a blow that could easily damage the engine.

The Steering Yokes Are Usually Separate Pieces, brazed to the ends of the axle, for which these parts are sometimes dropforged in one piece, it is more economical to make them separately.

REAR AXLES.

Dead Rear Axles, which are stationary, with the wheels running loose on the ends, are usually made as shown in Fig. 3, Chart 9.

The Body Springs Are Attached by Clips, as shown in Fig 3, Chart 9.

LIVE AXLES.

Live Rear Axles, which is the name given to axles that revolve with the wheels, are of two forms in one form the axle supports the weight of the car in addition to revolving the wheels, and in the other the axle only revolves the wheels, the weight of the car being carried by a tube through which the axle passes.

A Live Axle of any Type Is Made in Two Pieces, the differential gear being placed between its inner ends, and this makes it necessary to support the axle parts in a strong housing and to brace it, in order that the parts of the axle may not sag or get out of line.

Chart 10 Shows the Two Types Mentioned; in the first illustration the axle is driven by a single chain, and in the second by a driving shaft.

In Both Cases, the axle is contained in a housing which is a metal cover entirely surrounding it, the differential gear, which is in a smaller housing of its own, being also inside of the axle housing.

The Housing Extends to the Wheels, and is enlarged at those points to take the ball or roller bearings.

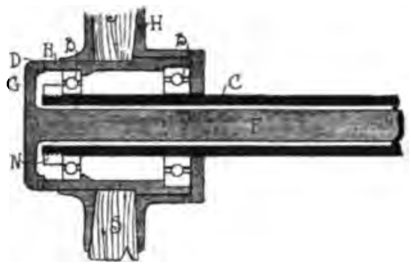


FIG. 4—FLOATING REAR AXLE

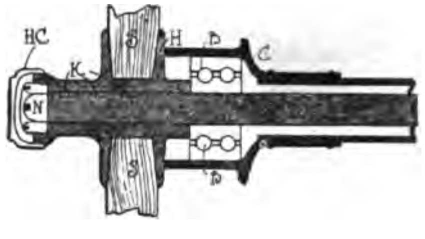


FIG 5—SEMI-FLOATING REAR AXLE

The "Semi-Floating" and "Floating" Type of Rear Axle explained.

In Fig. 5 a Semi-Floating type of rear axle is shown. In this construction the wheel is attached directly to the transverse driving shaft and secured thereon The driving shaft in this case not only serves to propel the wheel, but it also supports the weight of the car. The Hub H of the wheel in this illustration is a snug fit on the end of the transverse shaft F and the Woodruff keys K and the nut N serve to secure the wheel thereto. The hub cap HC is not absolutely necessary in this construction, as it merely serves as an ornament and to protect the nut N from being damaged by rust, bumps and other road hazards.

A Floating Type of rear axle is one in which the wheels have a bearing entirely upon the rear axle casing and no bearing whatever upon the transverse driving shafts, so that the weight of the car is carried entirely by the outer casing of the rear axle or axle tubes, as they are sometimes called, a clutch being used between the ends of the shafts and the wheel hubs to drive the wheels.

A Semi-Floating Type of rear axle is one in which the wheels are secured directly to the transverse driving shafts of the rear axle, these shafts not only serving to turn the wheels, but also to support the weight of the car.

A Floating Type of rear axle is illustrated in Fig. 4, C representing the axle casing, H the hub of the wheel, S the end of the spokes of the wheel, and B the bearings. It will be noticed that the wheel bears directly on the casing C and is held by the nut N. The driving shaft F has a flanged end G which forms a clutch that meshes with the outer edge of the hub H, the depth of the notches in the clutch and hub being represented by the dotted lines D. The clutch and shaft are held in place by the hub cap, and in this type of rear axle construction the transverse driving shafts F on either side of the driving gear and differential mechanism may be pulled out of the axle.

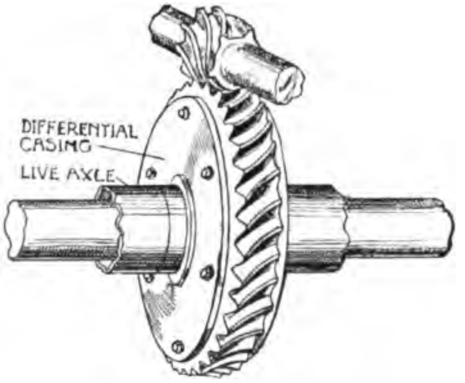


Fig. 6. Illustrates a New Type of Drive Gear gradually coming into favor.

It is the Worm or Screw Gear Drive. The Differential and Live Axle are on the same principle as in the ordinary Bevel Drive.

CHART No. 11.

These Bearings run between the axle and the inner side of the housing.

There Are Also Bearings at the inner ends of the two parts of the axle, close to the differential.

An Axle of This Type Must Be Heavy, as it supports the weight of the car.

FLOATING TYPE.

In the Floating Type of Rear Axle, the weight is taken from the axle, and supported on the housing through which the axle passes.

The Hubs of the Wheels Are Outside of the Housing, and the bearings are between the inside of the hubs and the outside of the housing. Chart 10 & 11.

The Axle Passes Through the Housing, and the ends that project are square over these square ends fit caps that screw or are bolted to the outside of the hub.

Thus When the Axle Revolves, the caps transmit the movement to the wheels.

As the Wheels Run on the Housing, the housing supports the weight, the axle serving only to turn the wheels.

By Removing the Caps, the parts of the axle may be drawn out without removing the wheels, which hold up the car whether or not the axle is in place.

By Jacking up the Car to take the weight from the wheel, the wheel may be drawn off the housing.

Because a Live Axle is not Continuous from side to side of the car, it is liable to bend down in the center, and this must be prevented by having braces at the center that are strong enough to resist the strain.

The Clips That Attach the Springs to the axle pass around the housing.

DIFFERENTIAL OR COMPENSATING GEARS.

It Is Necessary to Fit an Automobile with a differential or Compensation Gear, in order that the rear wheels may revolve at different speeds when the car turns a corner, while at the same time both are being driven by the engine.

This Gear Is Automatic, and operates according to the resistance of the road against the wheels.

There Is More Resistance to the turning of the inside wheel than to the outside wheel, and consequently the latter may revolve faster.

It Is Necessary for it to Revolve Faster, because it has a longer distance to travel than the inside wheel. (See Fig. 1, Chart 12, and note that if car is turning to the right the wheel "A" must revolve faster then wheel "B" therefore we must "compensate" for this difference.)

PRINCIPLE.

Stand Behind a Wagon, and put one hand on the tire of each wheel; push, if the vehicle moves straight ahead, the hands will move forward equally.

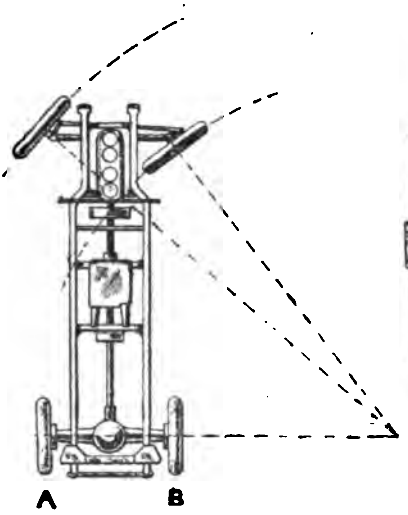


Fig. 1—Note that wheel "A" must make more turns than wheel B when car is turning curve.

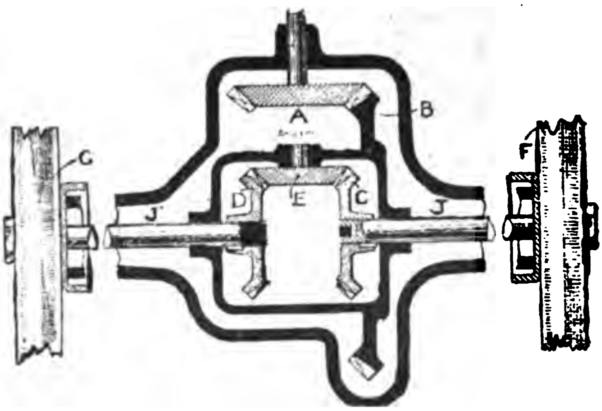


Fig. 2

A—Driving pinion on end of drive shaft.

B—Main bevel gear driven by A—B is attached to housing.

E—Small bevel gear carried on housing. There is also another gear E that connects the two gears at the bottom (not shown)

D—Bevel gears on axle.

G & F—Wheels.

J—Axle which is split.

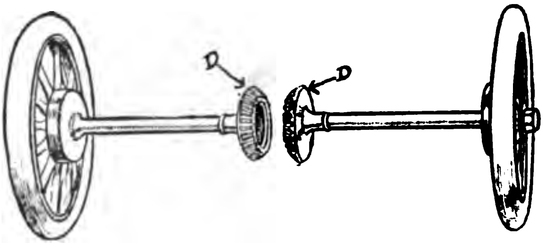


Fig. 4—Illustrates how the rear axle is divided into two parts.

Small bevel gears carried on the housing (see fig. 1, Chart 13) connects these two gears D.

(See Dyke's Working Model of a Differential for further explanation.)

Illustrations Explaining the Action of the Differential or Compensating Gears.

CHART No. 12.

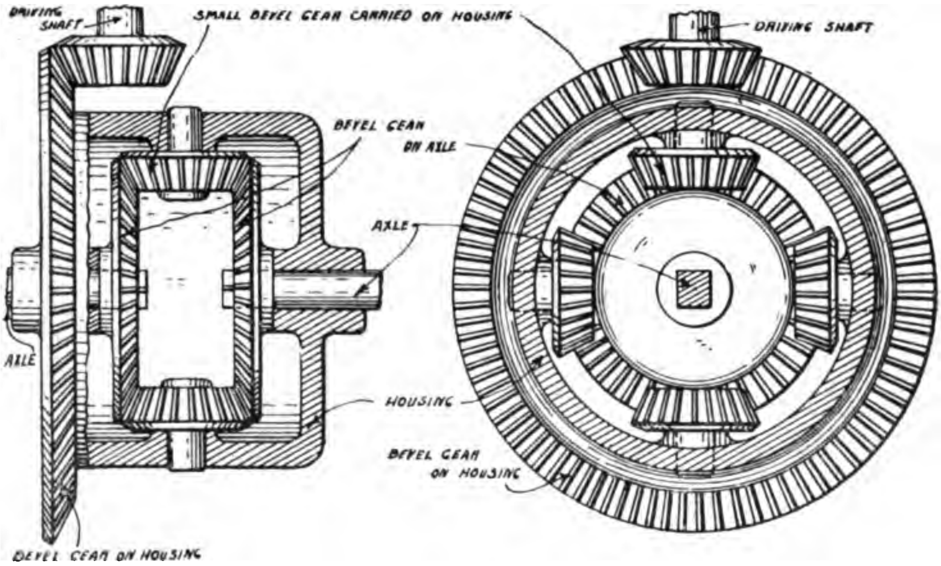


Fig. 1. **Fig. 2.**

The Bevel Gear Type of Differential.
All Gears are of the Bevel Type. Note the Axle is not solid.

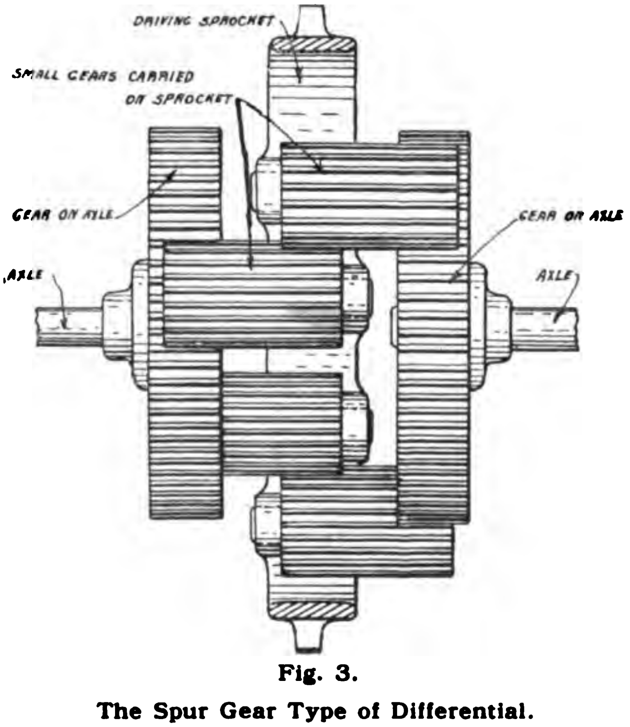


Fig. 3.

The Spur Gear Type of Differential.
All Gears are of the Spur Gear Type.

There are Two Types of Differentials; the Bevel Type and the Spur Gear Type.
A Differential is also called a "Compensating" Gear.
See chart No. 10 showing how and where a Differential is used.

CHART No. 13

If the Vehicle Turns, one hand will move farther ahead than the other, showing that one wheel moves more than the other.

Instead of the Hands, use a long stick, running it through the two wheels so that its ends press against the spokes.

Pressing Against the Center of the Stick will turn the wheels, and if the vehicle moves straight ahead, the stick will move forward evenly.

If the Vehicle Turns, one end of the stick will move ahead faster and further than the other, although the pressure is being applied to the center of the stick.

APPLICATION OF THE PRINCIPLE.

As Has Been Explained, when a differential is fitted to an axle, it is necessary to divide the axle into two pieces.

These Two Parts Are Placed End to End, in line with each other, the differential being placed between the ends.

The Simplest Form of Differential used for automobiles is called the BEVEL GEAR type, and in it a bevel gear is attached to the inner ends of the parts of the axle. (Chart No. 13, also see Dyke's Working Model of the Differential.)

The Housing That Contains the Differential is built so that it keeps the two bevel gears a fixed distance apart.

Between the Bevel Gears, and so placed that they are in mesh with both of them, are small bevel pinions, which may revolve on short shafts or STUDS.

The Studs Are Attached to a Ring, so that the bevel pinions are kept an even distance apart.

When the Ring Revolves, which it is able to do, the studs and pinions move with it, all revolving around the axle.

The Ring is driven by the propeller shaft of the driving chain.

To Understand the Action of the Differential, imagine the rear wheels to be jacked up so that they are free to revolve.

Turn the Ring by Hand, and the wheels will turn, because the bevel pinions are in mesh with both of the bevel gears.

As the Ring Turns, it carries with it the studs and pinions, and these latter take with them the bevel and axle and wheels.

With Both Wheels Free, they turn easily when the ring is revolved for the resistance is the same in both.

This Is What Takes Place When an Automobile Is Running Straight Ahead; the ring, carrying the studs and bevel pinions, is revolved by the driving shaft or chain, and the pinions force the bevel gears to revolve also, which makes the wheels turn.

With the Rear Wheels Jacked Up, hold one of them so that it cannot revolve, and turn the ring.

One of the Bevel Gears Is Now Stationary, while the other is free to move.

When the Ring Is Turned, the bevel pinions, being in mesh with the stationary bevel gear, will roll around it, revolving on their studs.

Being Also In Mesh with the Free Bevel Gear, they will make that **revolve with them,** and it will revolve twice as fast as the ring.

The Turning of the Ring in the first instance caused the wheels to revolve at the same speed which was the speed of the ring, and in the second instance it permitted one of the wheels to remain stationary while the other revolved at twice the speed, the ring always turning at the same speed.

If the Car Were to Make so Short a Turn that one of the wheels would be stationary, the car turning on it as if it were a pivot, the revolving of the ring would make the outside wheel turn at twice the speed at which it turns when the car is going straight.

With the Wheels Jacked up, hold one hand lightly against one of the tires, so that while the wheel can still turn, it will turn slowly, there being resistance to it.

When the Ring Is Turned, the bevel pinions will revolve slowly on their studs, rolling slowly around the bevel gear of the wheel that presents the resistance, and driving the free wheel faster than the ring is revolving.

The Slower One Wheel Revolves, the faster the other is driven, until one is stationary, when the free wheel revolves twice as fast as the ring.

When an Automobile Moves Straight Ahead, there is the same resistance to each wheel; the bevel pinions therefore will not revolve on their studs, but will carry the bevel gears around with them at the speed of the ring.

When Turning a Corner, there is more resistance to the revolving of the inner wheel than to the outer, and the bevel pinions will begin to revolve on their studs, driving the outer wheel faster than the inner.

With the Ring Revolving at a fixed speed, the outside wheel will revolve as much faster than the ring as the inner wheel is revolving slower.

In Other Words, if the ring is making fifty revolutions a minute, and the inner wheel is slowed to forty revolutions by the resistance of the turn, the outside wheel will make sixty revolutions.

To Comprehend the Action of a Differential Gear, it must be remembered that the bevel pinions are free to revolve on their studs, and that they are acted on by the drive, they in turn acting on the bevel gears to revolve the wheels.

SPUR GEAR DIFFERENTIAL.

In This Type, spur gears are used on the axle ends, instead of bevel gears.

The Ring That Is Revolved by the drive carries studs on which revolve other spur gears that are small in diameter, but long.

These Small Gears Are Arranged in pairs, which mesh as shown on Chart No. 13.

AT Their Inner Ends, each pair is in mesh, while the outer end of each gear of the pair is in mesh with one of the gears carried on the axle ends.

When the Driving Sprocket or bevel gear is revolved by the drive, it carries with it the studs and small gears.

If Both Rear Wheels present the same resistance, as when the car is running straight ahead, the small gears will carry with them the spur gears on the axle ends, without revolving on their studs.

If the Pair of Small Gears was in mesh only with the axle gears and not with each other, revolving the ring that carries them would only make them roll around on the axle gears, which would remain stationary.

They Would Revolve in the same direction in such a case, for they would both be traveling in the same direction around the axle gears.

Being in Mesh, as shown in the drawing, they cannot revolve in the same direction, for when two gears are in mesh they must revolve in opposite directions.

This Being the Case, the small gears cannot roll around the axle gears when the ring is revolved; if there is equal resistance to the turning of the wheels the small gears cannot revolve on their studs, but carry the axle gears with them as the ring turns.

If the Car Is Turning, one of the wheels will present greater resistance than the other, and the small gears will revolve on their studs, rolling slowly around the gear of the wheel that presents the resistance.

The Necessity for Dividing the Axle in order to fit in a differential gear is one of the weaknesses of live axle drive.

On Cars With Double Chain Drive, which have a dead rear axle, the differential gear is built into the jack shaft, where it supports no weight.

While the Bevel Gear Type Was the First to Be Used, the spur gear type has been largely adopted, as it is simpler to manufacture and adjust.

The Teeth of Spur Gears May Be Cut Without Difficulty, while the teeth of bevel gears require special machinery, exceedingly careful workmanship, and accurate adjustment.

There Is Nothing to Choose between the two types as far as efficiency goes.

While the Differential Gear Is Simple, it is better not to attempt to repair or adjust it without accurate knowledge.

It Is Always in a Dust-Proof Casing packed with grease, and should require little or no attention.

Note.—The Differential described are all shown housed on the rear axle. If the reader will refer to Chart 3, Fig. 1, he will observe that in this case the Differential is housed with the transmission. In other words, the Differential is just as important on one system as on the other.

BEARINGS.

If the Reader Will Observe the two axles in Chart No. 10, he will note the **Ball Bearings** in the one and **Roller Bearings** in the other.

Every Part of a Machine That Moves With a Rotary, Sliding, or Other Motion, is supported in bearings, to reduce the friction and wear.

The Ordinary Wagon or carriage wheel turns in PLAIN BEARINGS, as distinguished from the BALL BEARINGS of a bicycle wheel.

In a Plain Bearing, the moving and stationary parts touch all over, and are as smooth as possible.

In Ball Bearing, steel balls are placed between the moving and stationary parts, and roll between them.

The Friction of Two Parts Rolling Against Each other is much less than if the two parts slide against each other.

The Two Parts of the Bearing that the Balls Touch are called RACES, and are either flat or slightly curved.

The One or Two Balls at the lower side of the bearing support the entire weight, and each ball must therefore be strong enough to hold up without being crushed.

On Account of the Weight of Automobiles, the balls in the bearings are large, to prevent crushing, for if they were to be crushed, the pieces, not being able to fall out of the races, would ruin the bearing.

In Bicycle Bearings, the balls touch each other as well as the races, but as there is little weight on them, this makes no difference.

This Could Not be Done in a Large Automobile Bearing, for the wear of the large balls against each other would soon flatten them.

The Balls are Therefore Separated From Each Other, either by a metal separator, or by small coiled springs placed between each ball and those next it.

The Springs are Packed With Cotton, and as this is soaked with oil, the bearings are kept lubricated.

A Well Adjusted Bearing is Not Tight Enough to Bind, nor loose enough to have more than a very slight shake.

A Loose Bearing Will Permit Too Much Play, causing wear.

Roller Bearings are Similar to Ball Bearings in Principle, steel rollers being used instead of balls.

The Rollers Lie Between the Moving and Stationary Parts, and are sometimes the full length of the bearing.

In some Makes Two Sets of Small Rollers are Used instead of one set of long rollers, one set being arranged to screw in or out so that the bearing may be adjusted.

Ball or Roller Bearings are in General Use for automobile wheels and axles, and occasionally for the transmission and the main bearings of the crank shaft.

When a Clutch is Thrown In, there is a push endways on its shaft, in addition to the rotation.

This Push, Called the Thrust, Must be Taken Up, to prevent any end motion of the crank shaft speed gear shaft.

The Crank Shaft Bearings Prevent End Motion of the crank shaft but the change speed gear shaft is provided with a THRUST BEARING.

The Balls or Rollers of a Thrust Bearing are held in a retainer between the end of the shaft and a flat, fixed surface against which they may roll.

The Shaft is Thus Prevented From Moving Endways by a bearing that presents little resistance to its turning.

If the Shaft and the plain bearing supporting it are of the same metal ,the wear will be much more rapid than if two different metals are used, one harder than the other.

A Steel Shaft Will Wear a Plain Bearing also made of steel more quickly than if the bearing is made of brass or bronze.

Besides Brass and Bronze, which are much used for bearings, there are special metals made for the purpose, such as WHITE METAL, BABBIT, and others.

These Melt as Lead and Solder Melt, and a worn bearing can be easily recast.

The Scraping of a Bearing is explained further on.

The Lubrication of Bearings, as well as of all other parts of an automobile, is important, and the subject is covered further on.

PRESSURE ON A BEARING IS PRODUCED BY THE WEIGHT IT SUPPORTS AND THE GREATER THE WEIGHT THE GREATER THE PRESSURE.

The Pressure on One of the wheel bearings of an automobile, for instance, is produced by that proportion of the weight of the car that the wheel carries.

The greater the pressure on a bearing ,the larger and stronger it must be.

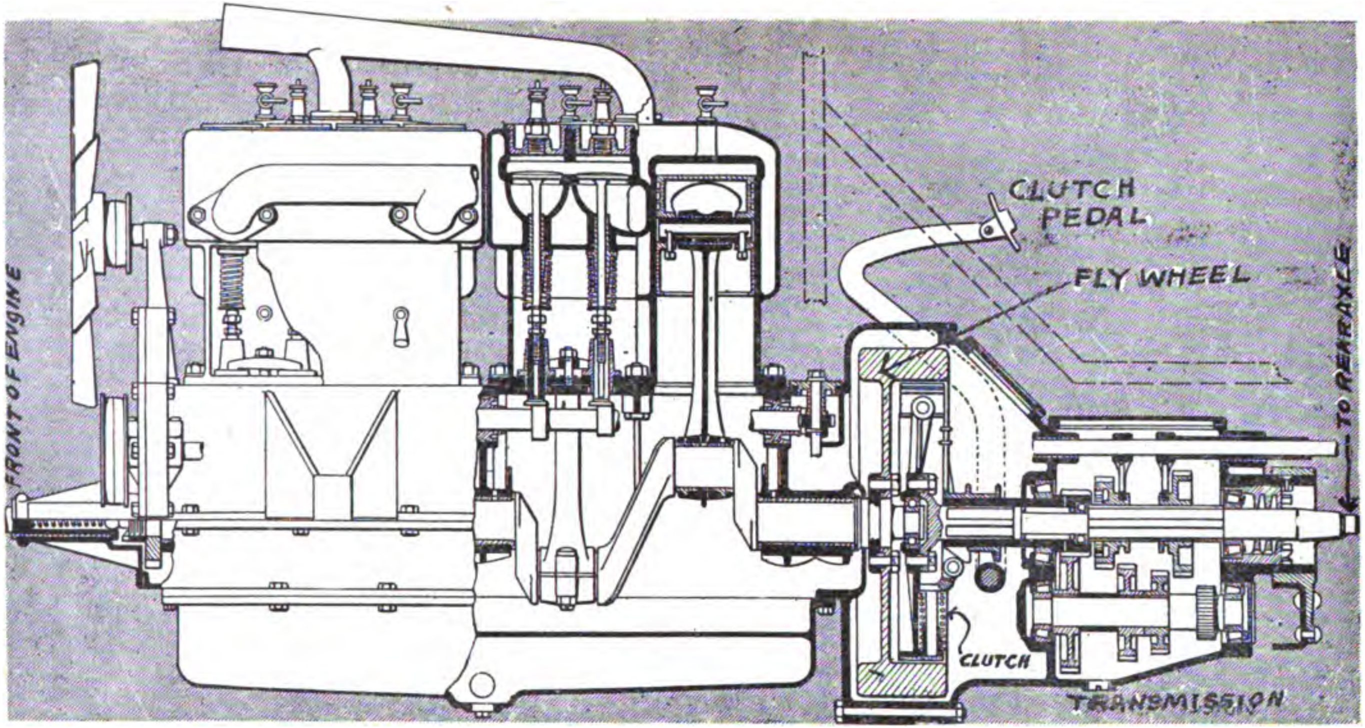


Illustration showing how the clutch operates in connection with the fly wheel of the engine. On pressing the clutch pedal with the foot the clutch is disconnected from the fly wheel of the engine, we then say: "clutch out" a term commonly used. This permits the engine to run without driving the rear axle. In other words the connection between the engine and the transmission or drive shaft is broken, consequently the power from the engine to the rear axle is disconnected.

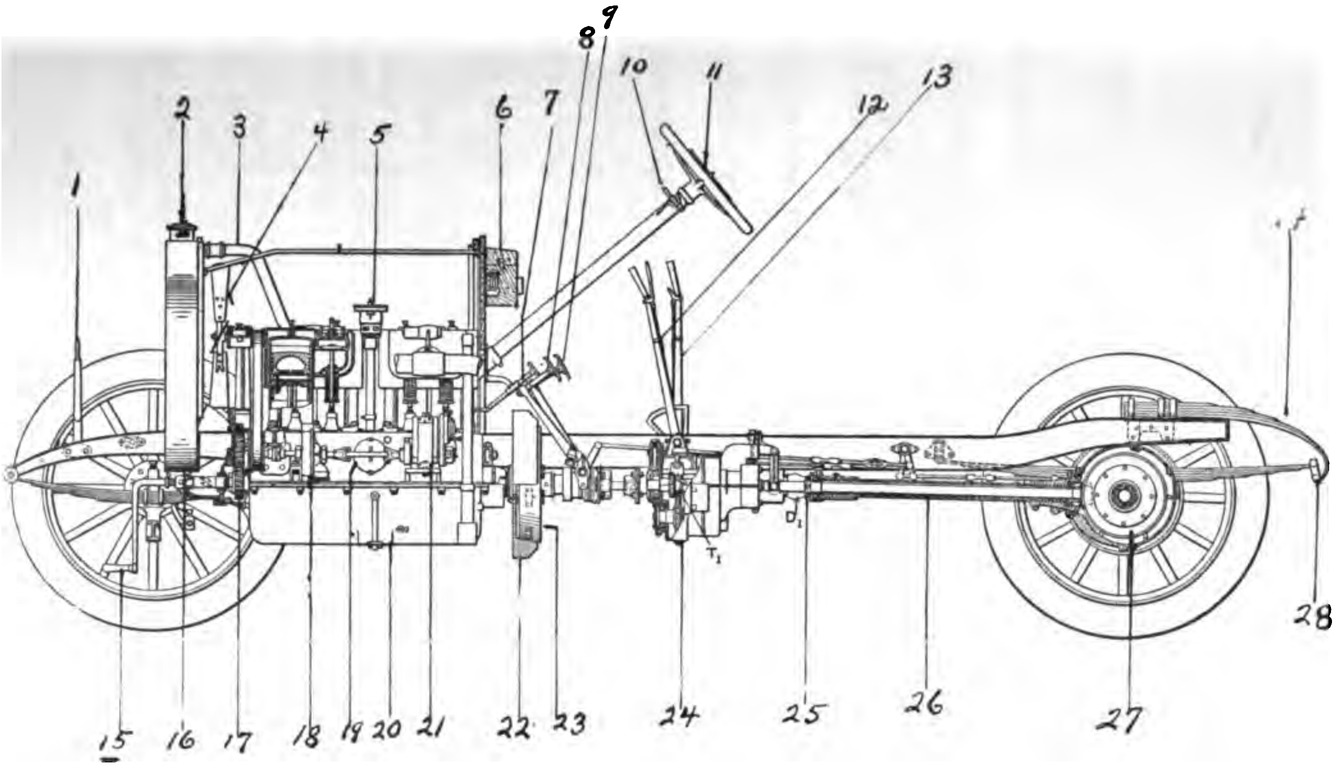
If the clutch is ' in" it connects with the fly wheel rim merely by friction with the inside of the fly wheel rim and the outer edge of the clutch. The reader will then note that there is no other connection between the engine and the transmission when the ' clutch is out," then the power of the engine is free and independent of the transmission and drive shaft.

The clutch is used by the operator of a car more than any other part of the car; for instance when starting engine the clutch must be "thrown out" so that the car will not start, this is usually done by the "hand brake lever" on the side of the car, being connected with the clutch so that it will hold the clutch out while the operator starts his engine.

After the operator is seated in the car the clutch is then operated by the foot and is constantly in use in that the operator slightly disengages his clutch on turning curves and on slowing down and picking up in crowded districts.

Above type of Clutch is the Internal Expanding Type. Full instructions for operating a car is given further on.

CHART No. 14.



Side view of a modern four cylinder, bevel gear drive automobile.

1 Lamp Bracket
2 Radiator, filler cap
3 Water connection from radiator to engine
4 Fan
5 Timer or commutator
6 Coil on dash
7 Accelerator
8 Clutch pedal
9 Brake pedal
10 Spark control, more frequently placed on wheel
11 Throttle
12 Gear shifting lever
13 Brake lever
14 Rear spring
15 Starting crank
16 Radiator bottom
17 Timing gears—operating cam shaft, pump and magneto
18 Circulating pump
19 Hand Hole Plate to get to cranks and inside of bottom of engine
20 Bottom of crank case—drain
21 Magneto. Operated from the same shaft as pump
22 Flywheel
23 Cone clutch
24 Transmission
25 Universal joint
26 Drive shaft
27 Differential
28 Spring clips

Illustrating the relation of one part of the car to the other. Note fig. 22 is the fly wheel and fig. 23 is the Cone clutch. If pedal (fig. 8) is pressed down by the foot, the clutch (fig. 23) is disengaged from fly wheel of engine (fig. 22) and thus the power line or shaft is broken. Fig. 13 is the "Hand Brake Lever" and also disengages the clutch when the brake is thrown on. The hand brake lever is seldom used only when standing to keep the car from moving if standing on an incline or so that operator can start engine.

The foot clutch lever or pedal and the foot brake lever are used while running to slow the car down.

CHART No. 15.

INSTRUCTION No. 5.

CLUTCHES.—Friction Cone Clutch, Multiple Disc, Care of Clutches. Universal Joints.

CLUTCHES.

The Word Clutch as used in conection with automobiles, indicates a device attached to cars having change speed gears of the sliding type, which permits the engine to be connected with, or disconnected from, the change speed gear, so that the car may or may not move while the engine is running.

While Other Types of Change Speed Gear Require Clutches, they are of special kinds, and will not be referred to in this lesson.

Because a Steam Engine has behind It the Pressure of the Boiler, it can be called on to supply much more than its regular horse power for short intervals.

A Gasoline Engine Has No Reserve Power to Call on, and cannot deliver more than a fixed horse power.

When the Gasoline Engine is Required to Start the Car, it must overcome the inertia of the car.

This Might be Greater than the Power of the Engine Could Accomplish, and the engine might be stopped instead of the car being started.

If the Clutch Made an Immediate Connection between the engine and the drive, the power of the engine would have to instantly overcome the inertia of the standing car.

The Power of the Engine coming from the revolving of the fly-wheel, and the explosion that might be occurring in one of the cylinders, it would probably be stopped instead of the car being started.

If, However, the clutch is made so that the engine takes hold gradually, the inertia of the car will be overcome, and it will move faster and faster as the clutch permitted the engine to apply its power more and more.

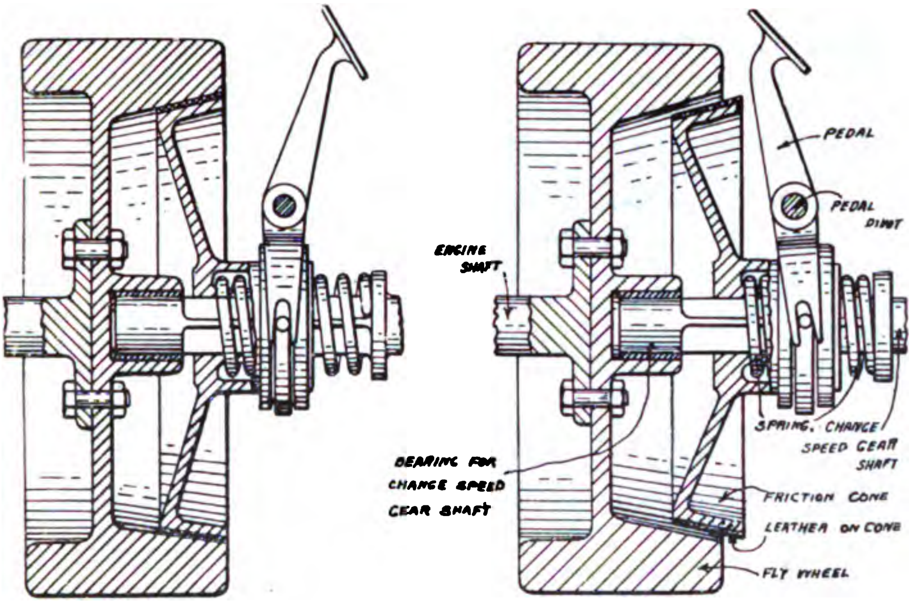
This is Done by making the clutch in such a way that when it is applied, it slips, instead of instantly making a connection between the engine and the drive.

When the Clutch is Thrown in, it connects the crank shaft with the change speed gear, and if the change speed gear is in the neutral position, the countershaft will revolve without moving the car.

When the Change Speed Gear is to be Moved to one of the speeds, the clutch must first be withdrawn, for the gears could not be meshed with the countershaft revolving and the square shaft stationary; withdrawing the clutch leaves the countershaft free to move as necessary to mesh the gears.

Clutches are of Three Types; the FRICTION CONE, INTERNAL EXPANDING, and MULTIPLE DISK.

These Have Two Chief Parts; one attached to the crank shaft, the other attached to the sleeve of the change speed gear.

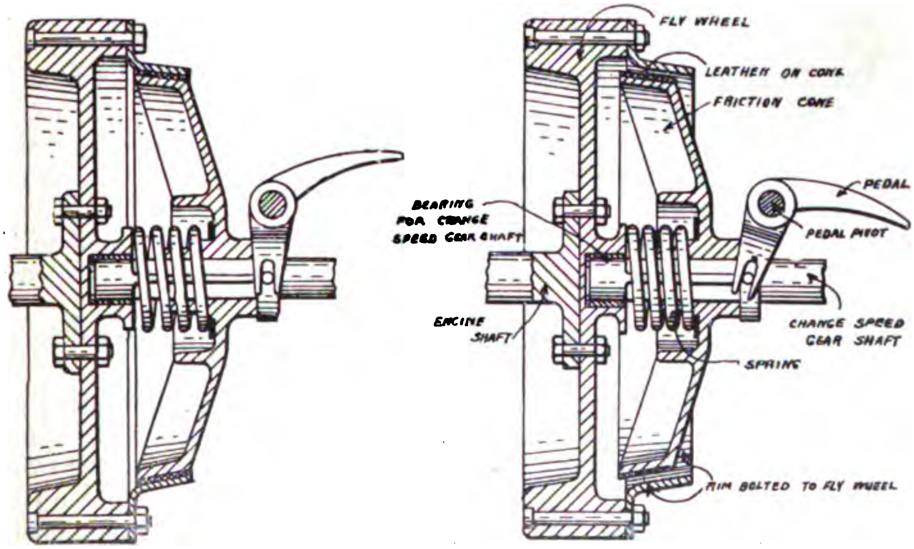

PEDAL
PEDAL PIVOT
ENGINE SHAFT
SPRING. CHANGE SPEED GEAR SHAFT
BEARING FOR CHANGE SPEED GEAR SHAFT
FRICTION CONE
LEATHER ON CONE
FLY WHEEL

THROWN IN

THROWN OUT

Fig. 1. The Cone Type of Friction Clutch.

Note in this type the spring forces the clutch in the fly wheel. This clutch is faced with leather and depends upon friction to connect the two together.



THROWN IN

THROWN OUT

Fig. 2. Another Form of Cone Type of Friction Clutch.

Note in this type the friction rim is bolted to the fly wheel and the friction cone works inside of this rim.

See chart 15 showing how the clutch is used on a car.

The clutch is used more by the operator in controlling the car than any other part of the machine and should be studied carefully.

The construction may vary, but all clutches are used for the same purpose.

CHART No. 16.

When These Two Parts are Separated; that is to say "thrown out," they are independent of each other and may move at different speeds, or one may move while the other is stationary.

When the Two Parts are Connected; that is to say when the clutch is "thrown in," the part on the crank shaft forces the other part to revolve with it, thus forcing the change speed gear to move with the crank shaft. (See Chart 14 and 15.)

The Part on the Crank Shaft Does Not Grip the part on the change speed gear immediately, unless they are moving at the same speed.

If They are Moving at Different Speeds, which is usually the case, or when the part on the change speed gear is stationary, the two parts slip.

This Slipping Continues until the two parts revolve at the same speed, when they bind together firmly.

When the Two Parts are Thrown Out, they must separate instantly.

FRICTION CONE CLUTCH.

This Type of Clutch is Built Into the Flywheel, and the flywheel forms one of its parts.

The Rim of the Flywheel is Broad, and the inside of the rim is made slightly funnel-shaped, forming the surface against which the other part of the clutch presses. (See Chart 14, 15, 16.)

The Other Part, Called the Cone, is, as its name indicates, cone shaped, and fits into the funnel formed inside the flywheel rim.

The Surface of the Cone that bears against the flywheel is often covered with leather to give good grip. (Fig. 1, Chart 16.)

The Hub of the Cone has a Square Hole, so that while it may slide on the square end of the sleeve of the change speed gear, the cone and shaft revolve together.

The Extreme End of the Sleeve Rests in a Bearing formed in the hub of the wheel, so that it is supported, and yet may revolve independently of the flywheel.

A Heavy Spring Presses the Cone Against the Seat formed in the rim of the flywheel.

The Multiple Disc Type is the Most Modern Form of Clutch, and it has a number of discs which are pressed together when the clutch is thrown in, the friction between them causing one to drive the other.

When the Foot Pedal is Pressed Forward, the cone slides on the shaft away from the flywheel, and separates from it, the spring being compressed.

When the Foot Pedal is Released, the spring presses the cone against its seat, and if the crank shaft and sleeve are not making the same number of revolutions, the cone will slip.

This Friction Makes the Cone Act as a Brake on the Crank Shaft, slowing it, and at the same time the cone and sleeve are speeded up, so that the cone and flywheel come to the same speed.

In the Reversed Friction Cone Clutch the flywheel rim is lighter, and to it is bolted a funnel-shaped rim, the inside of which forms the seat of the clutch. (Fig. 2, Chart 16.)

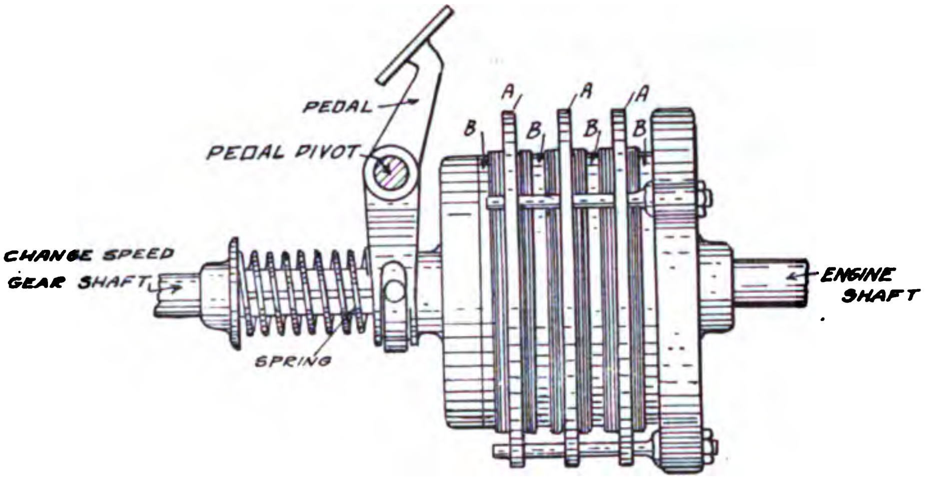


Fig 1. A Multiple Disc Type of Clutch.
This Clutch is used for the same purpose as the Friction Cone Clutch. It is a popular form of Clutch. It is used for the same purpose as the Cone Clutch and is sometimes built inside of the fly wheel.

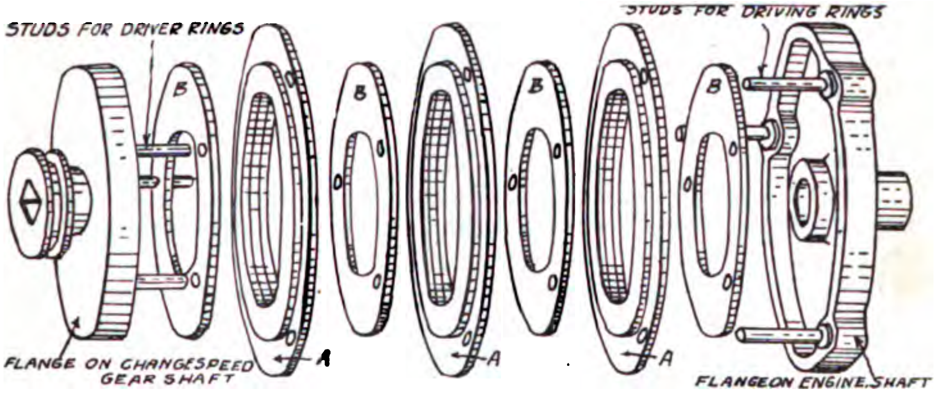


Fig 2. Parts of a Multiple Disc Clutch.
A—Driving Rings. B Driving Rings.
This type of Clutch is the Modern Type of Clutch employed by leading cars The plates on one make of transmission is made of asbestos, on a woven wire foundation for one plate and the other plate is made of smooth plates of steel.

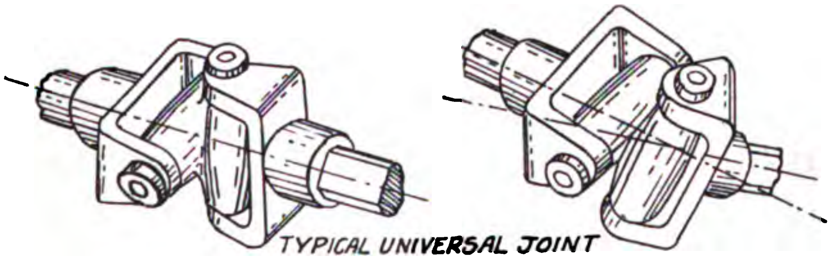


Fig. 3.

A Universal Joint.

See Chart 15 fig. 25 and 26. This will show how this Joint is used. Also see Dyke's Working Model of the Differential.

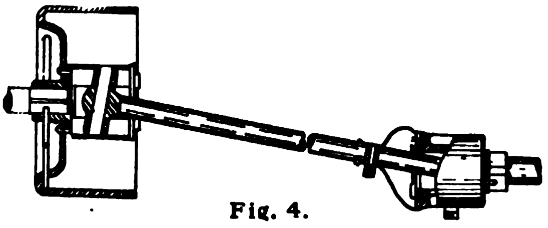


Fig. 4.
Universal Joint and Drive Shaft Connected.

CHART No. 17.

The Cone Moves Toward the Flywheel when thrown out, instead of away from it.

MULTIPLE DISC CLUTCH.

The Multiple Disc Type is the Most Modern Form of Clutch, and it it has a number of discs which are pressed together when the clutch is thrown in, the friction between them causing one to drive the other.

This Form is Compact, and reduces weight, but increases the number of parts.

To Illustrate the Principle of It, place a silver dollar between two silver half dollars, and squeeze them together between the thumb and forefinger of one hand.

With the Other Hand, try to revolve the dollar, not moving the halves.

It Requires Only a Slight Squeeze to produce sufficient friction to make it possible to move the dollar.

A Multiple Disc Clutch consists of a number of large and small discs or rings placed alternately, the large discs being controlled by the crank shaft, and the small discs being attached to the sleeve of the change speed gear.

Fig. 2 on Chart 17 shows the parts of the clutch separated from each other.

These Parts are a Flange attached to the crank shaft, a smaller flange attached to the change speed gear shaft, and the larger and small rings ,placed alternately.

In the Clutch Shown, the large rings are faced with leather to give a good grip.

The Two Flanges Have Pins Extending From Them, the rings having holes so that they may be slipped on the pins.

The Small Rings on their studs fit inside of the rims on the large flange, and the openings in the large rings permit the studs or pins on the small flange to pass through them.

Thus the Outer Edges of the small rings come in contact with the inner edges of the large rings.

As Will be Seen From Figure 1 on Chart No. 17, which is the clutch assembled, the two flanges are connected only by the friction between the large and small rings, when the spring presses the parts together.

The Entire Clutch is placed inside a casing, and runs in oil.

When the Pedal is Pressed Forward, the clutch thrown out, the oil flows between the rings, and when the clutch is thrown in and the spring presses the rings together, the oil is squeezed out from between them.

While It is Being Squeezed Out the Clutch is Slipping, and it begins to bind when the pressure has squeezed it out and the rings in consequence feel the effect of the friction.

When the Clutch is Thrown Out, one set of rings may revolve independently of the other, for they are not connected in any way.

While Leather Faced Rings Have Advantages, in many cases plain steel rings are used.

The Number of These May Be as High as Fifty; the larger the number the more smoothly the clutch takes hold.

INTERNAL EXPANDING TYPE.

Internal Expanding Clutches are built like internal expanding brakes, and the operation is the same. See brakes in Chart No. 8. Also see clutch in Chart 14.

The Drum against which the shoes act is attached to the crank shaft, and may or may not be built into the flywheel.

The Shoes That Bear Against the Inside of the Drum are of brass or bronze ,and a heavy spring keeps them expanded and in contact with the drum except when the pedal is depressed.

CARE OF CLUTCHES.

A Well Adjusted Clutch takes hold gradually, does not slip after it has come to a seat, and releases instantly when the pedal is depressed.

There Are Two Ways in Which a Clutch May Fail; it will continue to slip instead of coming to a firm seat, or it will bite suddenly instead of taking hold gradually.

A Slipping Clutch may be caused by: WEAK SPRING, WORN OR UNEVEN SURFACES, EXCESS OF OIL, THE PARTS BEING OUT OF LINE.

Tightening the Spring, or replacing a weak spring with a stronger one will remedy slipping from the first cause.

When the Surface of the Clutch and Seat Are New, they touch all over, but when worn, they touch on only the high places.

If the Surfaces Touch in Only a Few Places, they naturally cannot transmit the power that is possible with a good contact; they can be forced to transmit it by pressing them more firmly together, but it is better to reface the surfaces.

In a Leather Faced Clutch, it is always the leather that 'gives out, and this must be replaced.

The Leather is attached by means of copper rivets, which may be cut away with a chisel.

Hard Tanned Chrome Leather is Best for the Purpose, and should be carefully fitted.

When Riveted in Place, the leather should be trued; the cone should be set in a lathe and the surface filed true.

The Leather Should Neither Be Too Dry Nor Too Oily; the use of a good belt dressing is recommended, and the leather should have the same smooth appearance as a razor strop.

Castor Oil or Neat's Foot Oil May Be Used for Dressing the Leather, but should not be applied until all mineral oil has been removed, which may be done by sponging with kerosene—never with gasoline.

When a Friction Disc Clutch Slips Because of Too Much Oil, sprinkle powdered Fuller's earth over the surfaces, not using too much, and this will permit the car to be driven home.

The Leather Should Be Cleaned as soon as possible, and dressed with castor or neat's foot oil.

If the Leather Becomes Hard through drying out of the oil it will occasionally slip, although in this condition it is more liable to bite so to be "fierce" as is said.

When Through Use and Wear the change speed gear and crank shaft work out of line with each other, the cone will not seat properly, and will slip.

The Remedy is the lining up of the parts, which must be done in a well equipped machine shop, and by an expert mechanic.

Internal Expanding Clutches, in which metal acts on metal, sometimes give trouble from the melting of the metal due to the heat of excessive slipping.

This Will Lock the Two Parts of the clutch together so that pressing on the pedal will not release them.

To Separate Them, the engine must be stopped ,and the high speed gear engaged.

The Car Should Then be Pushed Forward and Backward by hand, which will jerk the clutch and release it.

The Same Trouble Occasionally Comes with friction cone clutches that are too fierce, and they may be separated in the same manner.

A Fierce Clutch After Being Treated With Oil should be thrown in very gently and easily, until the surfaces wear down.

UNIVERSAL JOINTS.

A Universal Joint is flexible connection between two shafts, which permits one to drive the other, although they may not be in line.

The Most Usual Form, shown on Chart No. 17, consists of forked arm on the ends of the shafts, and at right angles to each other.

Between the Forks is a piece of metal in the form of a cross, or a four-armed star, one pair of forks being pivoted to the ends of each pair of arms.

Each Shaft is Thus Free to swing around the arm to which it is pivoted ,and as the forks on the shafts are at right angles to each other, they may move in any direction.

It is Possible to have the shafts at a considerable angle with each other, without interfering with one being driven by the other.

Universal Joints are Necessary on automobiles with shaft drive, for while one end of the driving shaft is attached to the change speed gear, which is on the frame ,the other end is connected to the axle, and constantly moving up and down as the wheels follow the roughness of the road.

If No Universal Joints Were Used, the shaft would jam in its bearings from the up and down movement of one end of it.

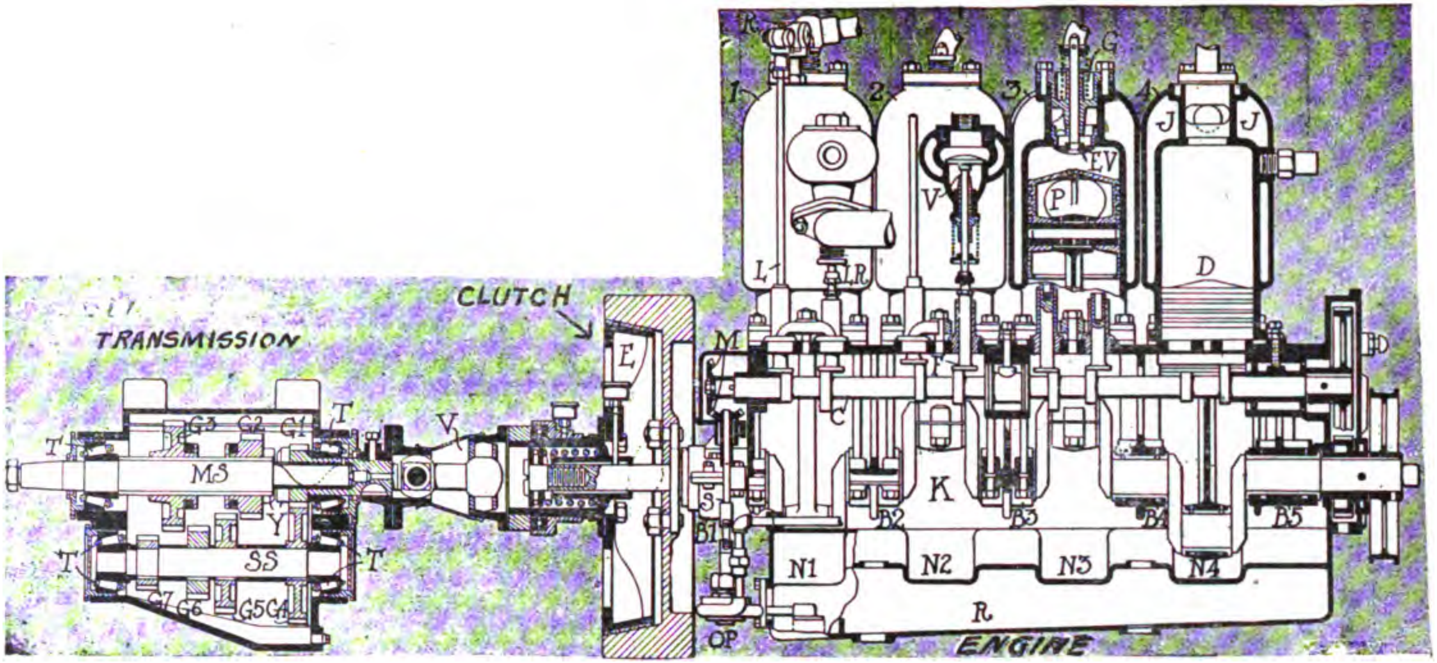
The Universal Joint Thus Prevents the movement of the axle from interfering with the turning of the shaft.

In Some Makes of Cars, two universal joints are used, one at each end of the shaft, which gives greater freedom of movement.

A Universal Joint is often used between the change speed gear and the clutch, so that the twisting of the frame cannot get the cone of the clutch out of line with the seat.

Universal Joints Must be Protected from dust and grit to prevent excessive wear, and it is also necessary to keep them well lubricated, they are always enclosed in metal or leather cases and packed in grease.

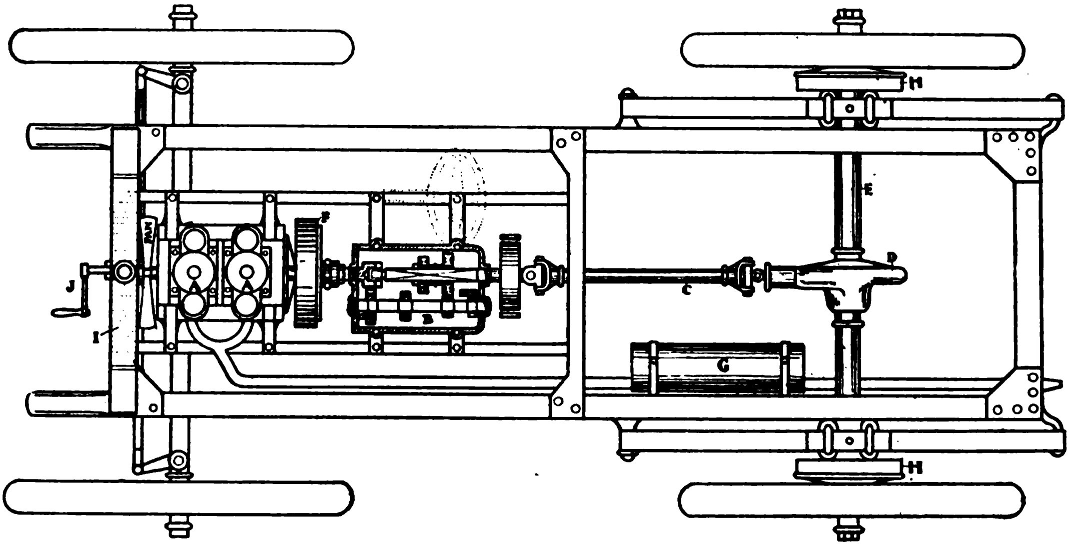
See Chart No. 15, Fig. 25 and note location of a universal joint on the drive shaft.



Illustrating first the engine, then the clutch in the fly wheel and then transmission connected to the clutch. By referring to Chart 19 and observing figure 1 the reader will note the usual location for the gear box or transmission.

Referring to Chart 18, MS is the main drive shaft of the transmission. SS is the secondary shaft of the transmission. G1 is the drive gear—this gear drives G4 which in turn drives shaft SS through the ratio of any one of the gears on the SS shaft to the gears on MS shaft. Note that the MS shaft is not solid but runs in a sleeve inside of G1 gear. Also note that G1 gear is connected with the clutch. This type of transmission is called the "Selective" type of transmission and is fully described further on.

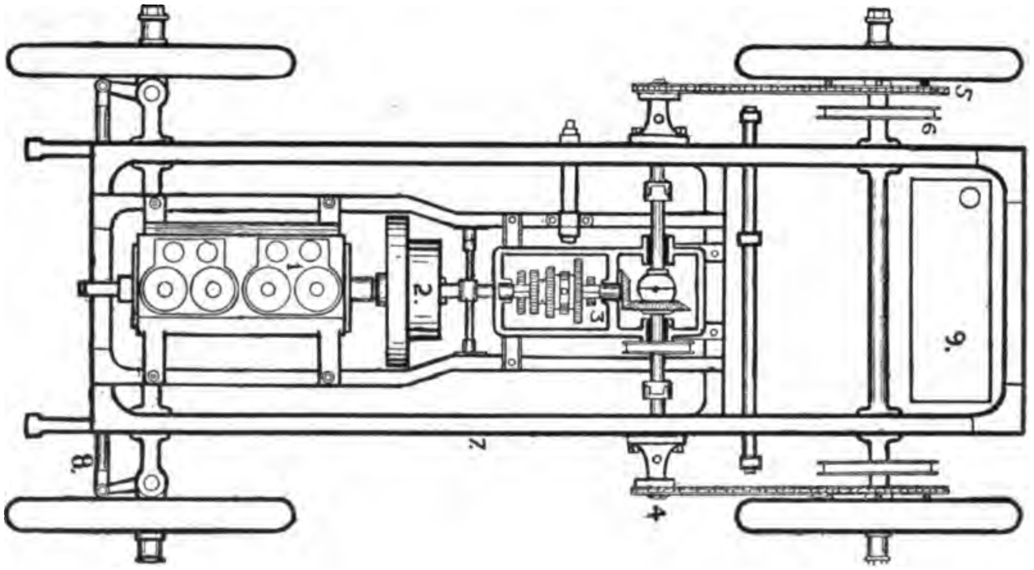
CHART No. 18.



Chassis of Car having a Propeller Shaft and Gear Drive.

(AA) Two-cylinder motor. (B) Gear box. (C) Propeller shaft. (D) Differential and bevel drive. (E) Live axle. (F) Clutch. (G) Muffler. (H) Brake drums. (I) Radiator. (J) Starting handle. (K) Universal Joint. (L) Exhaust pipe from engine to muffler.

Note the location of transmission and clutch. F



"Chassis" of Car fitted with Differential on Countershaft and Driving by Chains.

(1) Four-cylinder motor. (2) Disc clutch. (3) Change gears and differential countershaft. (4) Driving axle and chain sprockets. (5) Chain wheels. (6) Brake drum. (7) Frame work of channel steel. (8) Steering rod connecting steering axles. (9) Gasoline tank.

Illustrating the Transmission (3) with Differential in the same housing.

CHART No. 19.

INSTRUCTION No. 6.

CHANGE SPEED GEARS OR TRANSMISSIONS.—Sliding Gears, Progressive Type, Selective Type, Planetary or "Sun and Planet" Type, Friction Drive Type,—Combination Selective Transmission and Multiple Disc Clutch.

CHANGE SPEED GEARS.

Change Speed Gears, described in a general way in Instruction 1, are used to change the pull of the engine on the driving wheels, so that the car may run swiftly over a good road, or be able to climb a steep, rough hill.

This is Done by Connecting the Engine so that it makes many revolutions while the wheels revolve once, which gives the car slow speed but great force, or may revolve only a few times while the wheels revolve once, giving the car high speed.

The Number of Revolutions Made by the Engine to one of the wheels is different with different manufacturers, but as a general thing, when on the low speed the engine makes from twelve to eighteen revolutions to one of the wheels, and on high speed from one and a half to three revolutions to one of the wheels.

The Change Speed Gear may be built on any one of several systems, but those principally in use are the SLIDING GEAR and PLANETARY GEAR.

SLIDING GEAR.

In This Type, there are two shafts, one of which is driven by the engine and the two are connected by gears of different sizes. (See Chart 18-19.)

The Shaft not directly driven by the engine is square, and sliding on it are two or more gears, which may be made to mesh with the other gears on the shaft driven by the engine.

The Square Shaft may thus be driven fast or slow, according to the sizes of the gears in mesh.

There are Two Types of Sliding Gear; PROGRESSIVE and SELECTIVE.

PROGRESSIVE TYPE.

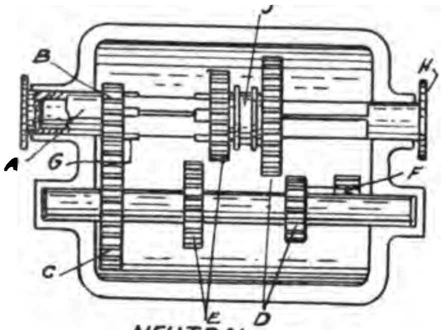
The Lever That Controls the Sliding of the Gears has but one movement forward and not backward. (See Fig. 1, Chart 23.)

When the Gears are Not in Mesh, the lever is straight up, and to change to the different speeds it is moved forward; a short distance for the low speed, and forward still more for the high speed.

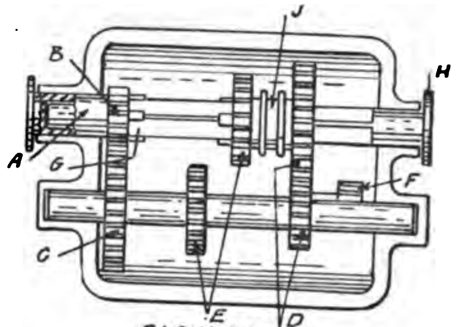
A Sliding Gear of the Progressive Type is shown in Chart No. 20.

There are Two Shafts, one being a continuation of the crank shaft, and another parallel to it, called the COUNTERSHAFT.

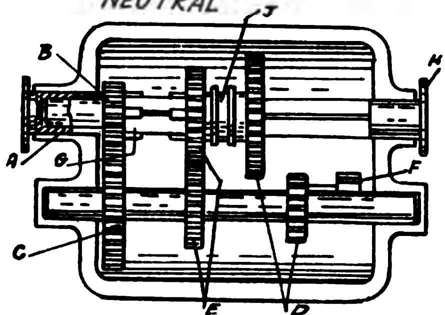
The Shaft in line With the Crank Shaft is in two parts, which turn independently of each other.



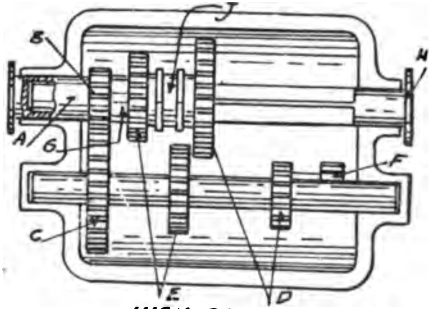
NEUTRAL



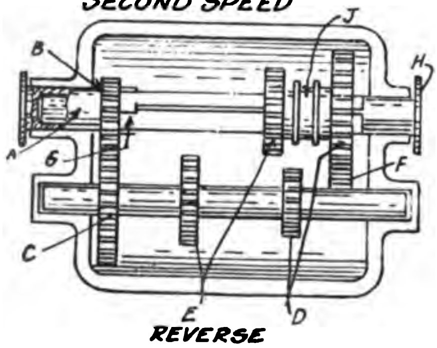
SLOW SPEED



SECOND SPEED



HIGH SPEED



REVERSE

The Old Style Progressive Type of Transmission.

In changing from one gear to the other in this Type of Transmission, it is necessary that the Teeth of the Drive Gear pass through the Teeth of the other gears.

The Type of Lever for Shafting these Gears is shown in fig. 1, Chart 23.

A—Sleeve Driven by Engine.
B Gear on Sleeve.
C—Gear on Countershaft.
D—Low Speed Gears.
E—Second Speed Gears.
F—Idler for Reverse.
G—Clutch for High Speed.
H—Connected to Rear Wheels.
J—Gear Sliding on Square Shaft.

CHART No. 20.

One of These Parts is Connected to the Clutch, and is driven by it.

It is Short and Hollow, and one end of the other part revolves within it and is supported by it, but not connected to it.

The Short Hollow Shaft, called a SLEEVE, ends with a small gear which is permanently in mesh with another gear on the countershaft.

Because of These Gears, the countershaft revolves when the sleeve revolves.

Except for the Bearings, the shaft in line with the sleeve is square, and on it slide two gears of different sizes, cut into one piece, and having a square hole through their hub that fits the square shaft.

Thus When the Gears Revolve they force the shaft to revolve also, but at the same time they may slide along it.

The Square Shaft is Connected to the Drive so that when it revolves it causes the driving wheels of the car to revolve also.

There are Three Gears on the Countershaft, of different sizes, and usually made into one piece with it for strength.

When the Gears on the Square Shaft are Slid Along they mesh with these gears on the countershaft.

In Chart 20 the Gears are Shown in the Neutral Position, in illustration marked "neutral;" that is, no gears are in mesh except those connecting the sleeve and the countershaft.

If the Engine is Running with the Gears in this Position, the countershaft is turning, but as the sliding gears are not in mesh with the gears on the countershaft, the square shaft is stationary.

To Get the Low Speed, (See Chart 20, "Slow Speed") the sliding gears are moved along the square shaft until the two low speed gears are in mesh, which causes the square shaft to revolve.

Because the Gear on the Sleeve is Smaller than the gear on the countershaft, the countershaft revolves slower than the sleeve.

Because the Low Speed Gear on the Countershaft is Smaller than the gear on the square shaft, the square shaft will revolve at a slower speed than the countershaft, and much more slowly than the sleeve.

To Get Intermediate Speed, (See Illustration in Chart 20 marked "Second Speed") the gears are slid along the square shaft until the intermediate gears are in mesh.

This Movement takes the low speed gears out of mesh.

The Intermediate Gear on the Countershaft being about the same size as the corresponding gear on the square shaft, the square shaft and countershaft will revolve at about the same speed, which is slower than the sleeve.

The High Speed of the Change Speed Gear illustrated in Chart 20, is called a DIRECT DRIVE, because the square shaft is made to revolve at the same speed as the sleeve by locking the two together by means of a clutch G.

This Is Done by Sliding the Gear still farther along the square shaft, so that a clutch formed by the ends of the gear and sleeve comes into contact, and causes the sliding gear and square shaft to revolve with the sleeve.

There Are Some Differences between the gear illustrated and the change speed gears of different types of cars, but the principle is clearly shown.

In Many Makes, the highest speed is not obtained by locking the square shaft to the sleeve, but by another pair of gears, similar to those of the low and intermediate speeds, but with a great enough difference in size to make the square shaft revolve at about the same speed as the sleeve.

The Sides of the Teeth of the gears are usually made like the point of a chisel, so that when two gears are brought together they will mesh easily.

If the sides of the Teeth Were Flat, as in ordinary gears, it would be difficult to slide them into mesh.

When Sliding the Gears From One Speed to Another, the main clutch must always be thrown out.

When the Car Is Running on the Slow Speed, the square shaft is revolving slower than the countershaft, and the intermediate speed gear on it revolving slower than the intermediate speed gear on the countershaft.

These Two Gears, Revolving at Different Speeds, must be put in mesh to get the intermediate speed, and therefore one of them must be free, so that its speed may suddenly be changed to the speed of the other.

With the Main Clutch in the Fly Wheel Thrown Out, the gear on the countershaft is free, and its speed may easily be changed.

If the Change Were to Be Made with the engine driving the countershaft, changing the speed of the gear would require the speed of the engine to be changed; or changing the speed of the gear on the square shaft would require the speed of the car to be changed.

Either of These Changes Would Be Sufficient to Strip the Teeth from the gears, or if the teeth were strong enough to stand it, the car would be badly jolted.

Therefore ALWAYS THROW OUT THE MAIN CLUTCH IN THE FLY WHEEL BEFORE CHANGING GEARS.

The Reverse Is Obtained through the use of the low speed gears. See Chart 20, illustration marked "Reverse."

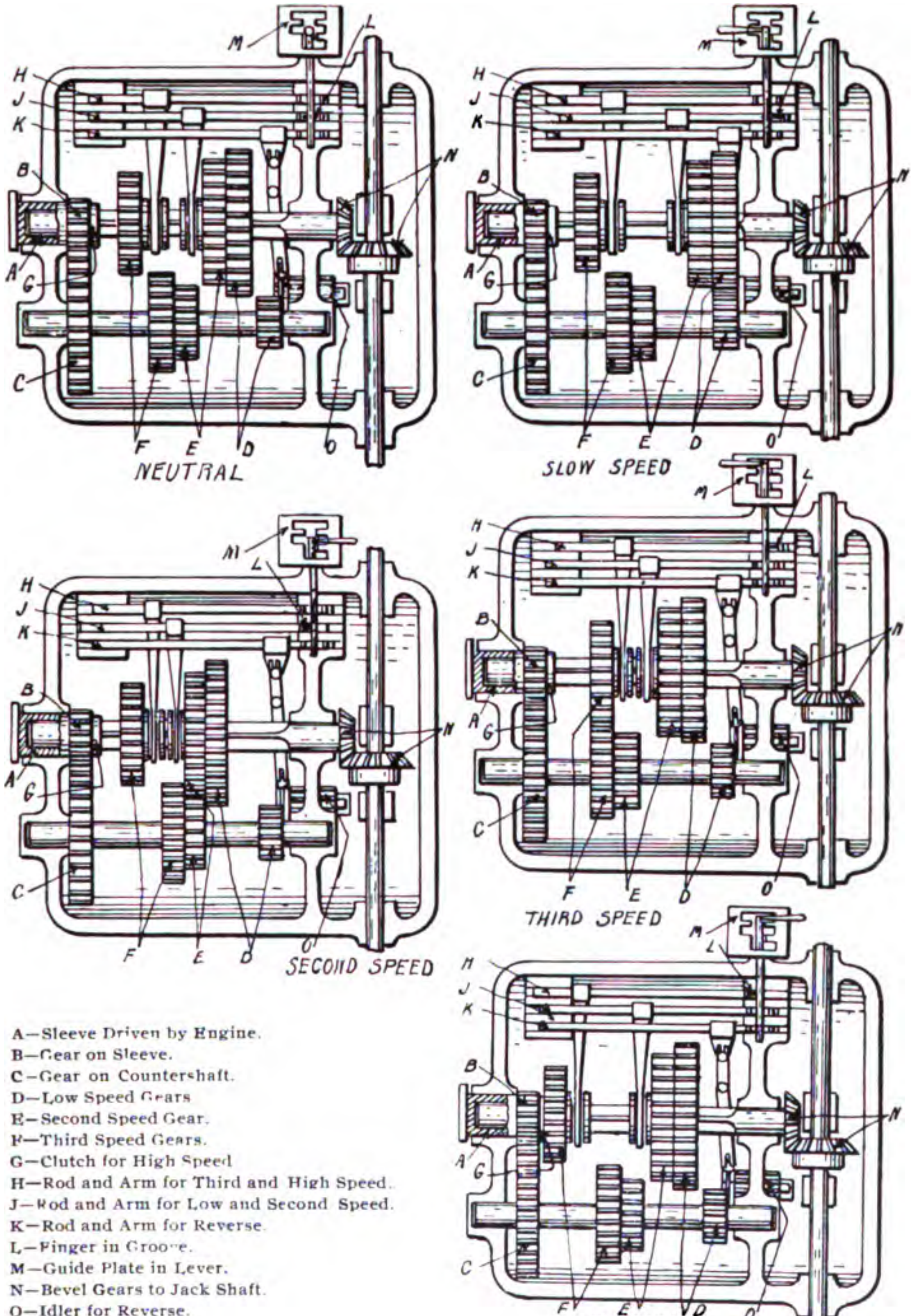
A Gear Called an Idler Meshes with the two low speed gears, reversing the direction in which the square shaft revolves, and also the movement of the car. See F.

THE SELECTIVE TYPE OF TRANSMISSION.

The Selective Type of Change Speed Gear is easier to handle than the progressive, but it is more expensive to manufacture.

In It the Action of the Lever that controls the gears is different from the lever of the progressive type, as it has two movements instead of one, moving in and out as well as backward and forward. (Fig. 2, Chart 23.)

The Arrangement of the Countershaft in the Gear Case is the same, the difference being in the gears on the square shaft.



A—Sleeve Driven by Engine.
B—Gear on Sleeve.
C—Gear on Countershaft.
D—Low Speed Gears.
E—Second Speed Gear.
F—Third Speed Gears.
G—Clutch for High Speed.
H—Rod and Arm for Third and High Speed.
J—Rod and Arm for Low and Second Speed.
K—Rod and Arm for Reverse.
L—Finger in Groove.
M—Guide Plate in Lever.
N—Bevel Gears to Jack Shaft.
O—Idler for Reverse.

The Selective Type of Transmission with Differential on Jack Shaft. Four speeds.
(See lower illustration, Chart 19.)

The Selective transmission is also the popular form of transmission on the propeller shaft driven car. (See Dyke's Working Model of a Transmission.)

In this type, the Gears do not pass through each other. The Lever and method for shifting the Gears of this type of Transmission, is shown in Chart 23 fig. 2.

The Selective Type is the Modern Type of Transmission now in general use.

CHART No. 21.

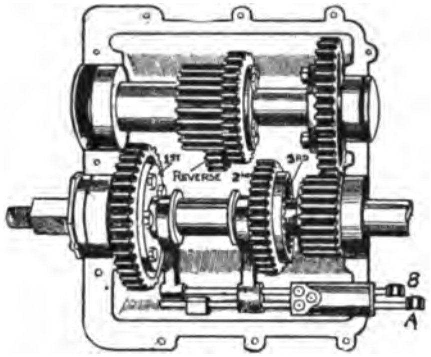


Fig. 1.

Fig. 1—Explanation of the Selective Type of Transmission 3 Speeds forward and one reverse and without the Differential or Jack Shaft.

System is the same as selective type of transmission explained in Chart 21 and is type of transmission used on shaft driven cars.

In this system there are two sets of gears which can slide independently on the lower shaft, but must turn with it by reason of the keyways and keys. Each gear sleeve is made to slide along the shaft by means of a fork and striking gear operated from a change-speed lever of the "gate" type. The three changes are obtained thus: 1st speed, the two left-hand wheels engage, and the other sleeve is kept out of gear. The lower shaft is practically in two halves, hence power is transmitted via countershaft, to first speed sleeve. 2nd speed is obtained by moving the 1st speed sleeve out of gear and the 2nd speed into gear with left hand pinion adjacent. The 3rd speed is a "through" drive got by sliding the 2nd speed sleeve to the right, when the internal gear engages with adjacent gear. The reverse is obtained by bringing the small pinion into mesh between the two intermediate gears. The actuating rods are locked automatically after meshing the gears by spring plungers engaging in depressions cut in the rods.

CHART No. 22.

The Change Speed Gear shown on Chart 21 is of the selective type, with four speeds forward and reverse, one speed more than the progressive type shown on Chart No. 20.

By Four Speeds Forward It Is Meant that four combinations of gears may be made, giving four changes of speed to the car while the engine runs at one speed.

The Square Shaft bears two sets of sliding gears instead of one and they move independently of each other.

The Gears Are Moved by arms that project from rods that slide lengthways in bearings on one side of the square shaft.

When These Rods Are Slid Along, the gears attached to their arms move also, sliding along the square shaft.

The Control Lever, on the side of the car at the driver's seat, moves forward only a short distance for each speed, and also slides away from the car or toward it, according to slots in the plate that guides it. See Fig. 2, Chart 23.

The Lever Is Attached at Its Lower End to a rod that is rocked in its bearings when the lever is moved forward or backwards, or slides endways when the lever is moved toward the car or away from it.

This Rod Extends to the Gear Case, and at its end has a finger extending downward.

This Finger Catches in Grooves cut across the ends of the rods that move the gears.

When the Rod Is Rocked by the Lever, this finger, being in the groove of one of the rods, pushes that rod endways, which slides the gear to correspond.

Chart No. 21, at the Top, Shows the Gears in the Neutral Position; that is, the countershaft may revolve without revolving the square shaft, none of the gears being in mesh except those connecting the sleeve to the countershaft.

The Grooves in the Rods that control the gears are in line when the gears are in this position, and therefore the control lever may be slid endways, the finger moving through the grooves without moving the rods.

Chart 21, at the Right Side at the Top, Shows the low speed gears in mesh.

The Control Lever has been moved until the finger is in the groove of the rod that controls the low speed gear, and has then been pushed forward, which has rocked the rod and turned the finger so that it has pulled the gear rod endways.

The Arm Attached to the Rod slides the low speed gear into mesh with the gear on the countershaft, and the square shaft revolves.

For the Second Speed, the control lever is pulled back to the center of the guide plate, and then still backward so that the finger slides the rod in the opposite direction, which brings the second speed gears into mesh.

The Slots in the Guide Plate Are so Arranged that when the lever moves into one of them the finger is in correct contact with the proper groove.

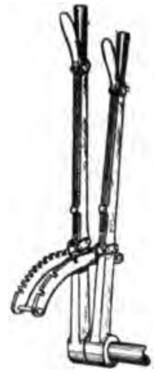


Fig. 1—The old style Levers used on the old style Progressive type of Transmission. Inside Lever shifts gears. Other Lever is Brake Lever.

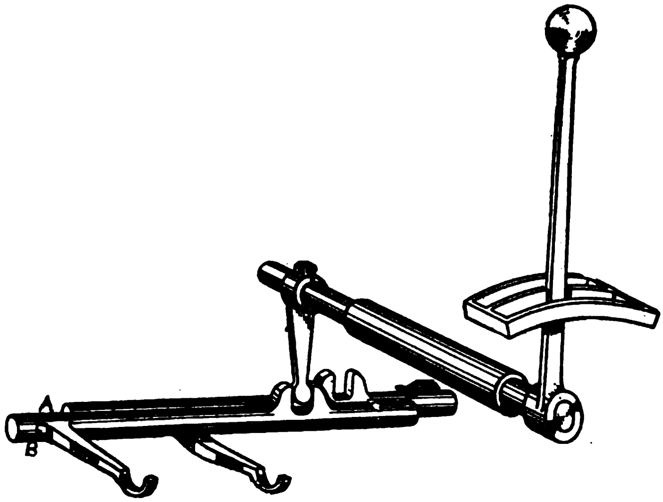


Fig. 2—The One Lever for operating the Selective Type of Transmission. This Lever works sideways as well as endways.

Fig. 2 - Style of lever is called the Gate principle of change-speed gear lever. The long vertical hand lever can be moved both endways and sideways in the gate quadrant The transverse shaft carries an arm which can engage one of a series of slotted lugs on the "selector" bars. which have forked extensions which engage the respective gear wheel sleeves. Only one sleeve at a time can be actuated; the non-operative selector bar is held in position by a spring catch, so that its gear sleeve is kept out of mesh.

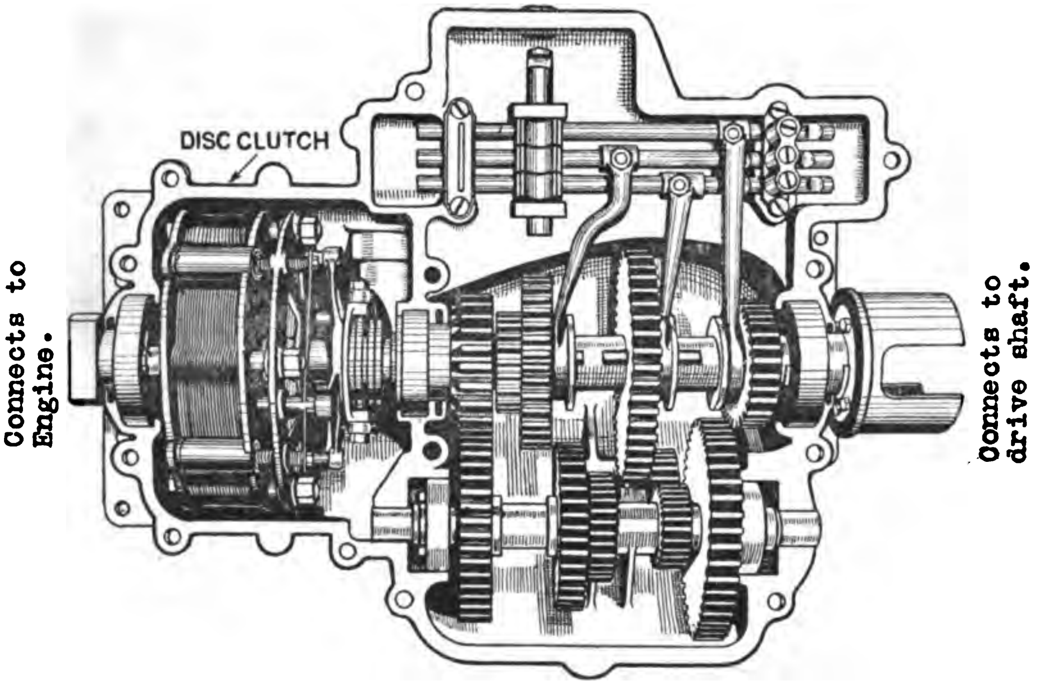


Fig. 3—Showing a modern Selective Type of Transmission and a Multiple Disc Clutch combined in one case.

Illustration is of a 4-speed gearbox, designed on the selective gear principle. The fourth speed is indirect, the through or direct drive being on the third speed, obtained by moving left-hand sleeve further to left; moving it to the right to mesh with countershaft pinion gives the second speed. Moving the next sleeve to left gives the first speed, and to right gives the reverse. The fourth indrect gear sleeve is on extreme right, and is moved to the left and engages large countershaft pinion. The disc clutch arrangement forms a complete unit with the gearbox.

CHART No. 23.

For the Third Speed, the lever is brought to the central position, which draws the gears out of mesh and into the neutral position, and then moved away from the car, so that when it is pushed forward it will enter the outside slot of the guide plate.

Pushing It Forward Rocks the Finger, and that is now in the groove of the rod that controls the third speed gears. Chart 21.

Pulling the Lever Back so that it is in the back half of the outside slot moves the third speed gear into contact with the sleeve, and a clutch locks them together, so that the square shaft revolves with the sleeve and consequently with the crank shaft.

The Inside Slot of the Guide Plate corresponds with the rod that controls the reverse gear, which moves endways until in mesh with the two low speed gears.

Change Speed Gears of This Type Are Often Made So that the direct drive, which is the clutching together of the square shaft and the crank shaft, is the third speed.

For the Fourth Speed, gears are used that make the square shaft revolve at a higher speed than the crank shaft.

This Fourth Speed Combination Drives the Car at a Speed that is possible only on perfect roads, and most of the driving is done on the direct drive of the third speed.

PLANETARY CHANGE SPEED GEARS.

Planetary Gears Are in General Use for Runabouts, and are satisfactory because the teeth of the gears cannot be stripped.

The Principle Under Which the Type Operates is more difficult to understand than that of the other types of change speed gears, and therefore a careful study of the illustration on Chart No. 24 is recommended.

The Diagrams on Chart No. 24 do not show the construction of planetary gears as they are used, but serve to illustrate the principle.

The Planetary Does Not Require a Main Clutch, as does the sliding gear, but is placed directly on the engine crank shaft.

To the Crank Shaft Is Attached a Gear, which turns with it. A; Chart No. 24.

Around this Gear Are Four Other Gears of the Same Size, meshing with it. B, Chart No. 24.

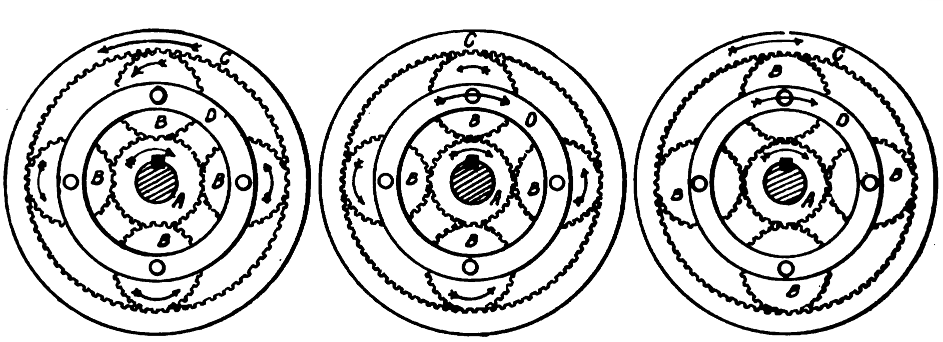
Outside of the Four Gears Is a Drum with teeth cut on the inner side, called an INTERNAL GEAR. C, Chart No. 24.

The Four Gears Mesh With the Internal Gear as well as with the gear on the crank shaft.

The Shafts, called STUDS, on which the four gears revolve are set in a metal ring, so that the distance between the gears always remains the same. D, Chart No. 24.

"Reverse" Shows the Change Speed Gear in the position that drives the car backwards, called the reverse position.

The Crank Shaft and gear attached to it always revolve in the same direction, because it is not possible for a gasoline engine to run backwards in an automobile.



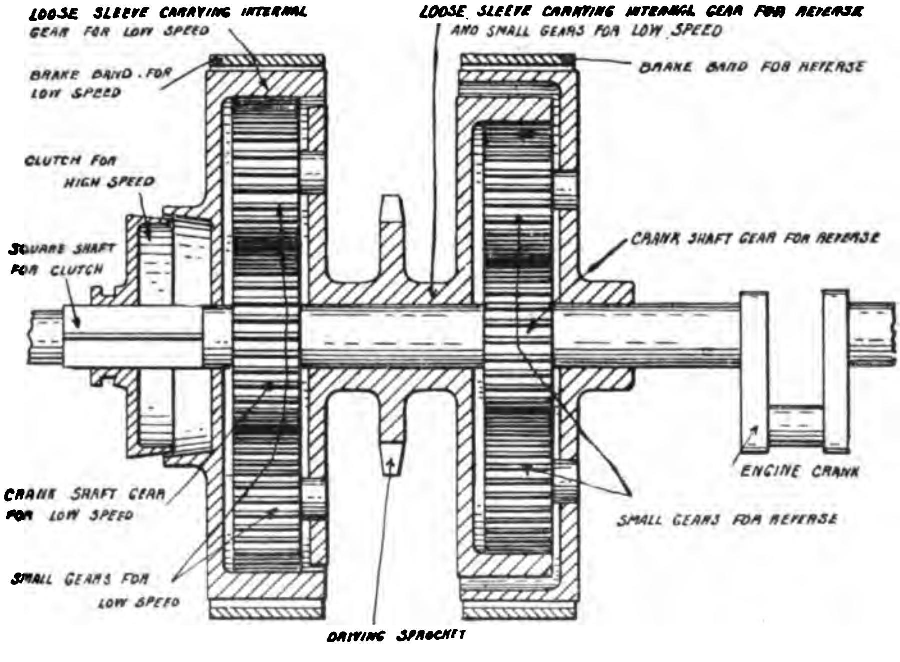
REVERSE
INTERNAL GEAR C REVOLVING. RING D STATIONARY. SMALL GEARS B AND SHAFT GEAR A ALL REVOLVING

SLOW SPEED
INTERNAL GEAR C STATIONARY. RING D, SMALL GEARS B AND SHAFT GEAR A ALL REVOLVING

HIGH SPEED
INTERNAL GEAR C, RING D, SMALL GEARS B AND SHAFT GEAR A REVOLVING WITH ENGINE SHAFT

The Planetary Transmission.

The explanation of this gear is explained in this instruction No. 4.


LOOSE SLEEVE CARRYING INTERNAL GEAR FOR LOW SPEED
LOOSE SLEEVE CARRYING INTERNAL GEAR FOR REVERSE AND SMALL GEARS FOR LOW SPEED
BRAKE BAND FOR LOW SPEED
BRAKE BAND FOR REVERSE
CLUTCH FOR HIGH SPEED
SQUARE SHAFT FOR CLUTCH
CRANK SHAFT GEAR FOR REVERSE
ENGINE CRANK
CRANK SHAFT GEAR FOR LOW SPEED
SMALL GEARS FOR REVERSE
SMALL GEARS FOR LOW SPEED
DRIVING SPROCKET

The Planetary Type of Transmission is sometimes called the "Sun and Planet" type. This type of transmission is used generally on runabouts and seldom used on heavy cars. It is the type used on the Ford and Buick type of car.

CHART No. 24.

To Drive the Car Backwards, the gears must be so arranged that the driving sprocket goes in the opposite direction to the crank shaft.

To Get This Result With the Planetary Gear, the ring that supports the four gears is held stationary.

In Revolving, the crank shaft gear therefore makes the four gears revolve on their studs.

When the Four Gears Revolve on their studs, they force the internal gear to revolve also, because it is in mesh with them.

It Can Be Seen From the Diagram that the internal gear will revolve in the opposite direction to the crank shaft, and if the internal gear is so attached that it drives the car, the car will run backwards.

Chart 24 at the Top, "Slow Speed" Shows the Combination for the slow speed forward.

For This the Ring Is Released, and the internal gear is held stationary and prevented from revolving.

The Crank Shaft Gear Being in Mesh with the four gears, they would revolve with it if they were free from the internal gear.

Because They Are in Mesh With the Internal Gear, and because that is held stationary, the small gears roll around it, revolving on their studs, and carry the ring around also.

A Simple Experiment That Will Illustrate This Movement of the four gears and their ring around the crank shaft gear is to take a pill box, napkin ring, or some similar object, and crook a forefinger around it.

Place a Pencil Between the Pill Box and the Finger, and with the other hand revolve the box.

This Will Make the Pencil Revolve, and as the finger is stationary, the pencil will roll along it.

The Pill Box Represents the Crank Shaft Gear, the pencil one of the four small gears, and the finger the internal gear.

As the Four Gears Move Around the Crank Shaft Gear, the ring moves also, because the studs on which the four gears revolve are attached to it.

The Ring Will Move in the Same Direction as the Crank Shaft Gear, but more slowly, for the following reason:

Suppose That the Crank Shaft Gear and the Four Gears each have the same number of teeth, fifty, for instance, and that there are two hundred teeth on the internal gear.

In Rolling Around on the Internal Gear, each of the four gears would have to make four revolutions in order to get back to the place where it started, because in one revolution they would only travel over fifty teeth of the internal gear, or one-quarter the way around.

The Crank Shaft Gear and the Four Gears having the same number of teeth, they travel at the same speed, and as it takes four revolutions for the four gears to roll entirely around the internal gear, the crank shaft gear will make four revolutions in the same time.

The Ring Moves With the Four Gears, and would therefore make one revolution while the crank shaft gear makes four.

If the Ring Is so Connected that it drives the rear wheels, they will turn slowly, and the car will move on the low speed.

Chart 24, at the Top, to the Right, Shows the High Speed, there being no intermediate.

The Drum, the four gears and their ring, and the crank shaft gear are locked together so that they revolve as one piece, all moving at the speed of the crank shaft.

The Diagrams Show Only the Principle of the Planetary Gear, Chart 24, showing the practical arrangement as used on various light runabouts, with the exception of the end clutch, which is changed for the sake of clearness.

It Will Be Noticed that there are two sets of crank gears, gears and rings, and internal gears, one set being for the reverse and the other for the low and high speeds.

The Crank Shaft Gears Are Attached to the Crank Shaft, and always revolve with it.

A Sleeve Is Slipped on the Shaft Between the Two, and may revolve on it.

On the Right Hand end the sleeve carries an internal gear; at its center is the driving sprocket that is connected to the rear axle by a chain; on its left end is the ring that supports the studs on which one set of four gears revolves.

The Set of Four Gears surrounding the other crank shaft gear is carried on another sleeve that is slipped on the crank shaft to the right of the gear, the sleeve being free to revolve on the shaft.

A Third Loose Sleeve Is Slipped on the Shaft to the Left, forming an internal gear, and at the center of which a clutch may be applied.

Brake Bands, forming single acting brakes, surround both sets.

When the Brake Band on the Right Is Tightened, it bears against an extension of the sleeve that carries the four gears, and when the brake band on the left is tightened it binds the outside of the internal gear.

Thus by Means of These Brake Bands it is possible to hold stationary either the ring supporting the four gears surrounding the right hand crank shaft gear, or the internal gear of the left hand set.

A Ring Shaped Projection of the Left Hand Sleeve forms one part of a clutch, the other part being a cone-shaped piece that fits inside of the ring.

The Cone-Shaped Piece Has a Square Hole That Fits the Shaft, which is square at that point, so that while it may slide on the shaft it turns with it.

For Backing the Car, the reverse brake band is tightened, so that the ring carrying the four gears is held stationary.

As in Chart 24, at the top, to the left, **This Turns the Internal Gear in the Opposite Direction** to that in which the crank shaft gear is turning, and as the driving sprocket is in one piece with the internal gear, the axle is turned in the reverse direction, and the car backs.

For the Low Speed Forward, the reverse brake band is released, and the other brake band tightened.

This Holds the Low Speed Internal Gear Stationary, and the four gears in mesh with it roll around, carrying the ring with them.

This Ring Also Being Part of the Sleeve Bearing the Sprocket, the axle turns, and the car moves forward on the low speed.

For the High Speed, the low speed brake band is released, and the clutch thrown in.

This Locks the Sleeve bearing the internal gear fast to the engine shaft, and the result is that as the four gears are in mesh with the crank shaft and internal gears, and both of these are locked to the crank shaft, the small gears revolve with them, but do not revolve on their studs.

This Makes the Sprocket Revolve at the speed of the crank shaft, and drives the axle and car to correspond.

When One Brake Band Is Tight, the other is loose, and one set of gears is turning idly, without working.

The Brake Bands must be kept tight enough to do their work, but must not bind when not in use.

As the Brake Band Will Slip before the teeth will strip ,the planetary gear is safe in the hands of a novice.

For an Emergency Stop, the reverse may be applied in addition to the regular brakes of the car, and is frequently used in this manner.

The Brake Bands Are Lined With Leather, and must be kept free from oil, that they may not slip.

The Leather Is Easy to Replace when worn, as it is a straight strip, held to the steel band by copper rivets.

Another Explanation of the Planetary Transmission.

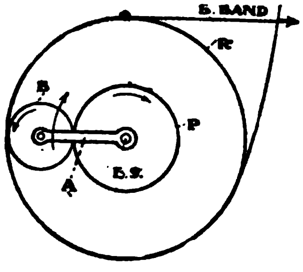


Fig-1

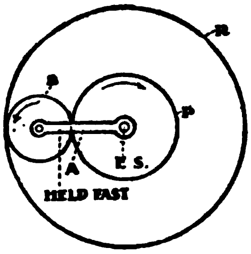


Fig-2

R is a ring with teeth cut on the inside (Fig. 1,) P is a toothed pinion keyed to the engine shaft, while A is an arm revolving on that shaft, but not keyed thereto. This arm (A) has a short axle at its extremity, which carries another pinion (B) gearing with the internally-cut ring (R), as well as with central pinion (P). Now, suppose P to turn round once with the engine shaft in the direction of arrow; R, at the same time, being held fast by a brake-band. Since P turns in this direction it is evident that B must turn in the opposite direction, as indicated by the arrow within B. Consequently, B's teeth pressing against those of R (which are stationary) will tend to make B move along the inside of R in the direction shown; this will, of course, compel the arm (A) to advance in that direction also, as shown by another arrow.

As stated, P is keyed to the engine shaft, so coupling the arm (A) to the road wheels by a clutch or other suitable means, we shall get (A) moving the road wheels at a certain speed. This gives the first speed.

If now the brake-band on R be loosened, and the wheels comprising the gear are clamped or locked together the whole will revolve en bloc in the same direction and at the same speed as the engine shaft. This is the second, and highest, speed. Again, if the arm (A) be disconnected from the road wheels and prevented from revolving (Fig. 2)—P still turning in the same way—B still revolves in the opposite direction, as shown, and the teeth on B, pressing those on the inside of R, will cause R to revolve in the opposite direction to P, and also in the opposite direction to that of the two previous occasions. This, then if R be coupled (similarly to the manner in which A was before) to the road wheels, gives the reverse. It will be seen that this single train of epicyclic gear obtains two speeds forward and reverse. In order to procure three or more speeds forward it will be necessary to add another element or some corresponding device; but enough has been said to explain how the gear works. It must, of course, be understood that the action has been explained in a purely diagrammatical way, and that, in actual practice, modifications are made, suitable means introduced to couple up the road wheels to the gear, etc.

CHART No. 24A.

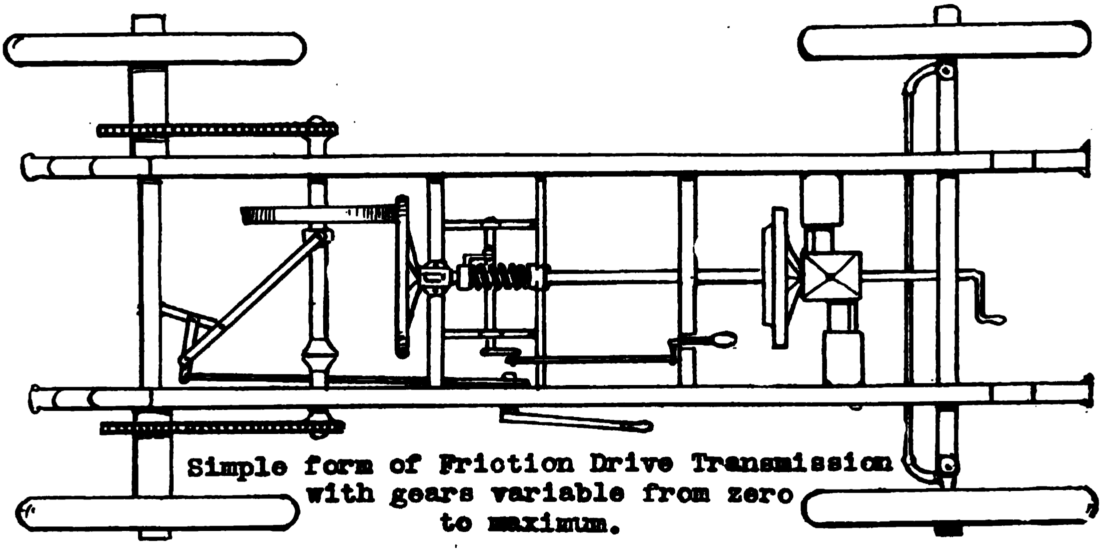
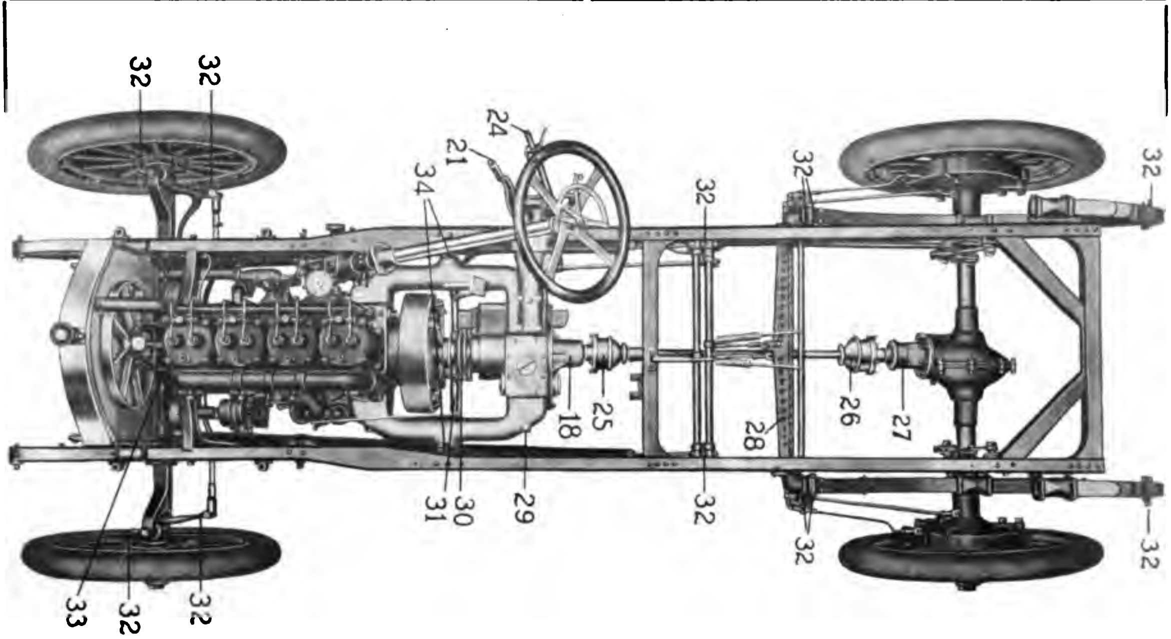

Simple form of Friction Drive Transmission
with gears variable from zero
to maximum.

Fig. 1—Another Type of Transmission; The Friction Drive. In this type the Clutch and Gearbox is eliminated.

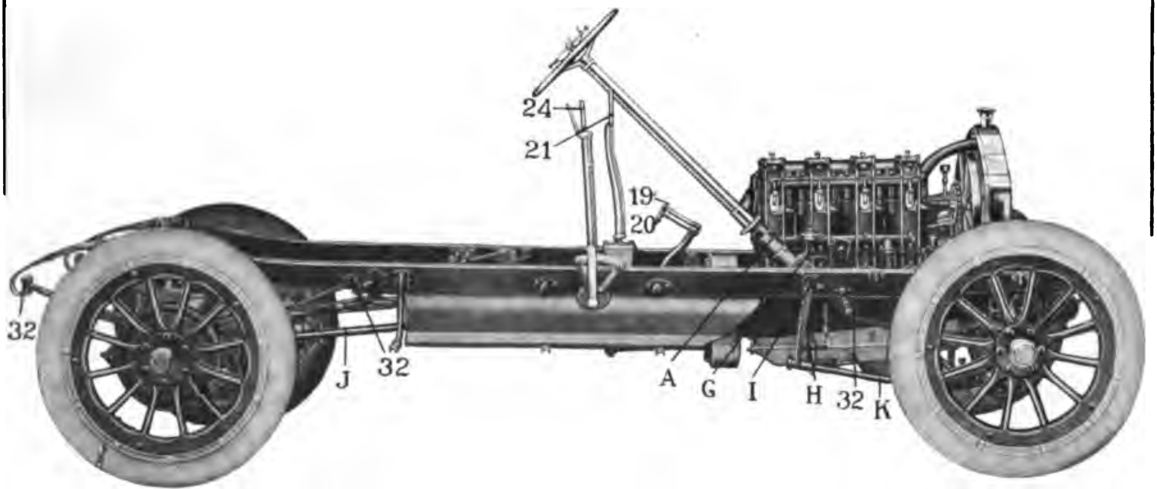
This is the simplest form of transmission applicable to motor cars. In principle it consists of a rotating steel disc of large diameter fitted on the engine shaft, and mounted at right angles to it is a shaft carrying a wheel, the rim or edge of which is faced with fibre or leather. The wheel is capable of being moved on a keyway right along the shaft by means of a forked lever. Sufficient pressure is provided by a spring to bring the disc and friction wheel into close driving contact. The countershaft will then revolve at a speed and direction depending on the position of the wheel relative to the disc. If at the exact centre, the speed will be zero, or nothing, and as it is gradually brought farther along towards the edge the speed will increase to a maximum. If moved right across to the other side of the disc the motion is reversed. By withdrawing the disc out of contact with the friction wheel, by means of a pedal or lever, the engine is left running free or in neutral gear. The whole arrangement, therefore, comprises a clutch and all-speed gear forward and reverse.

CHART No. 25.



Top view of Chassis of a 40 H. P. Automobile.

18 Rear end transmission plate
25 Front universal joint
26 Rear universal joint
27 Pinion universal joint
28 Brake equalizing bars
29 Side arm bolt
30 Clutch brake link
31 Brake lever cross rods
32 Grease cup
33 Trunnion motor support
34 Rear power plant support

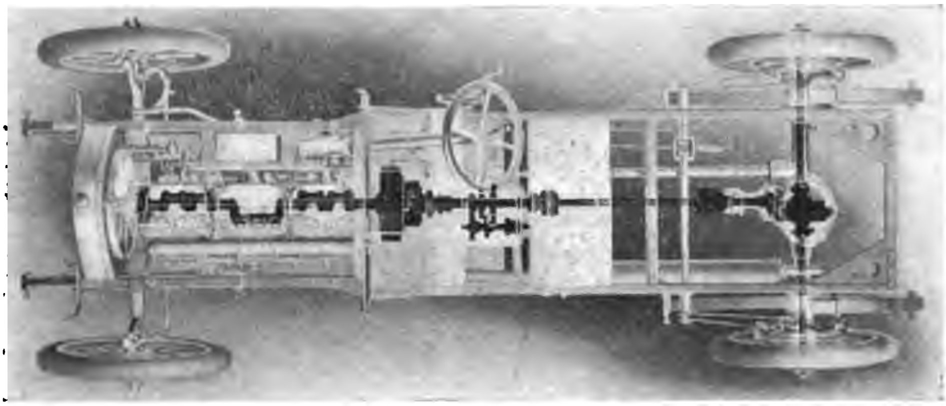


Side view of Chassis of a 40 H. P. Automobile.

19 Clutch pedal
20 Foot brake pedal
21 Gear shift lever
24 Emergency brake lever
32 Grease cups
A Steering gear adjustable nut and counter collar
G Steering gear oil plug
H Steering gear bell crank
I Steering gear bell crank shaft
J Radius rod
K Fore and aft steering rod

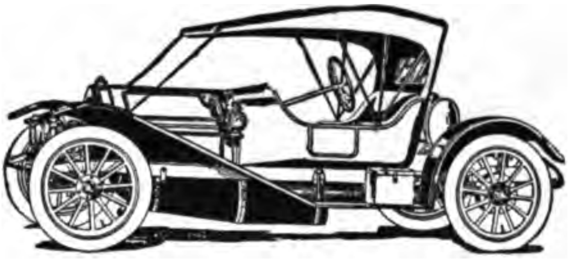
A Study of the Photographs of the Top and Side view of a Modern 4-Cylinder, Shaft Driven Car.

CHART No. 26.

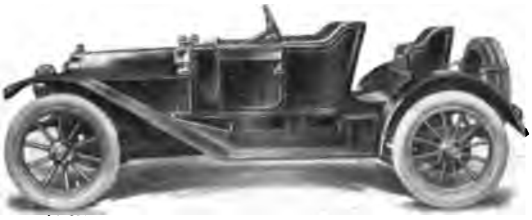


A Phantom of the Model Chassis Showing a Propeller Type Design of Drive Line from Motor to Rear Hubs.

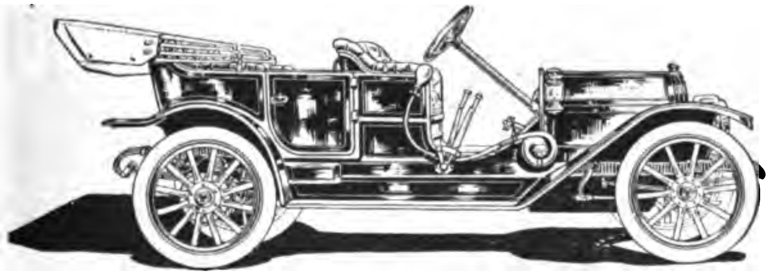
NAMES OF THE VARIOUS TYPES OF CARS.



RUNABOUT

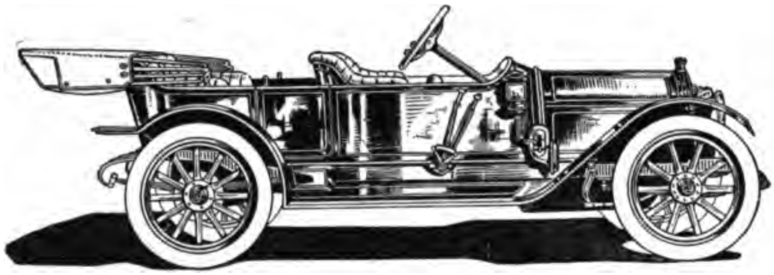


FORE DOOR ROADSTER



MEDIUM SIZE TOURING CAR

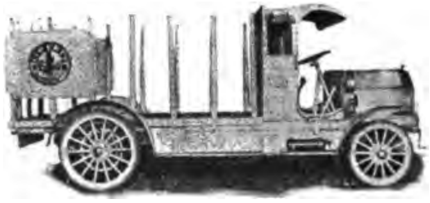
CHART No. 27.



SEVEN PASSENGER TOURING CAR

A MOTOR DELIVERY WAGON

LIMOUSINE.



A TRUCK

TOWN CAR, also style used for Taxicab service when fitted with a Taximeter.

ELECTRIC COUPE

CHART No. 28.

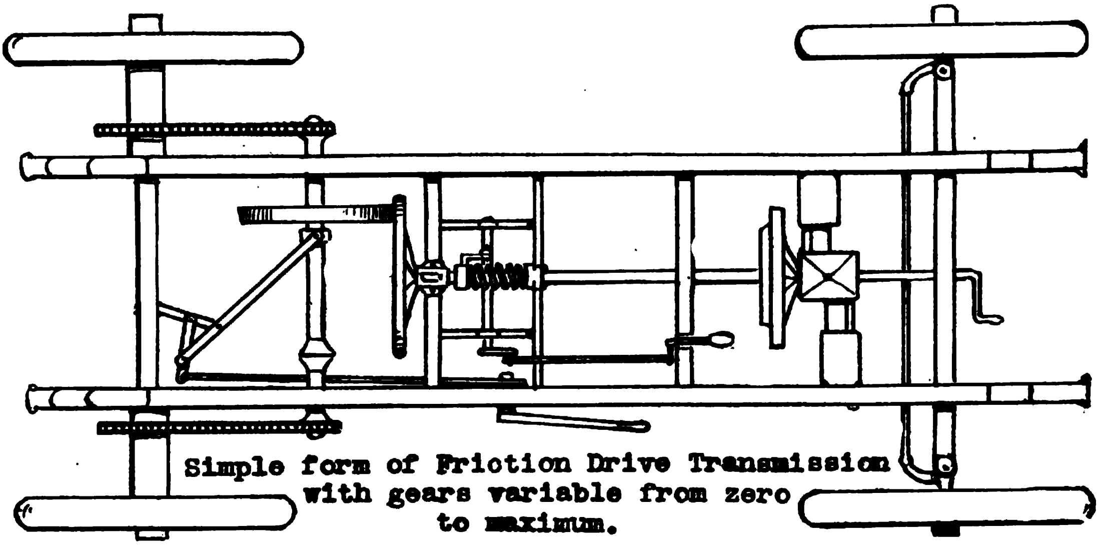
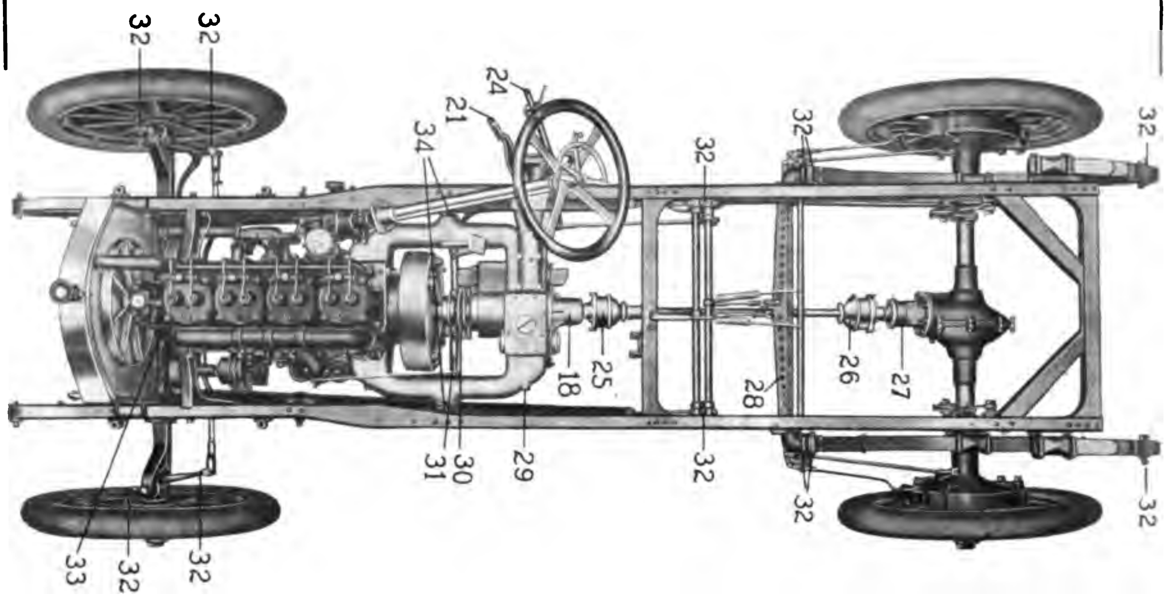

Simple form of Friction Drive Transmission with gears variable from zero to maximum.

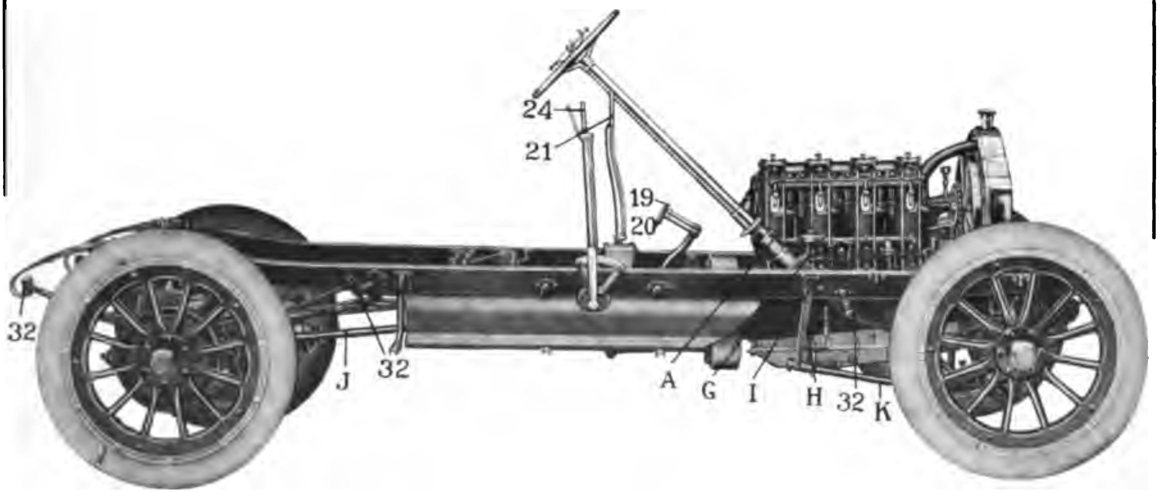
Fig. 1—Another Type of Transmission; The Friction Drive. In this type the Clutch and Gearbox is eliminated.

This is the simplest form of transmission applicable to motor cars. In principle it consists of a rotating steel disc of large diameter fitted on the engine shaft, and mounted at right angles to it is a shaft carrying a wheel, the rim or edge of which is faced with fibre or leather. The wheel is capable of being moved on a keyway right along the shaft by means of a forked lever. Sufficient pressure is provided by a spring to bring the disc and friction wheel into close driving contact. The countershaft will then revolve at a speed and direction depending on the position of the wheel relative to the disc. If at the exact centre, the speed will be zero, or nothing, and as it is gradually brought farther along towards the edge the speed will increase to a maximum. If moved right across to the other side of the disc the motion is reversed. By withdrawing the disc out of contact with the friction wheel, by means of a pedal or lever, the engine is left running free or in neutral gear. The whole arrangement, therefore, comprises a clutch and all-speed gear forward and reverse.



Top view of Chassis of a 40 H. P. Automobile.

18 Rear end transmission plate
25 Front universal joint
26 Rear universal joint
27 Pinion universal joint
28 Brake equalizing bars
29 Side arm bolt
30 Clutch brake link
31 Brake lever cross rods
32 Grease cup
33 Trunnion motor support
34 Rear power plant support

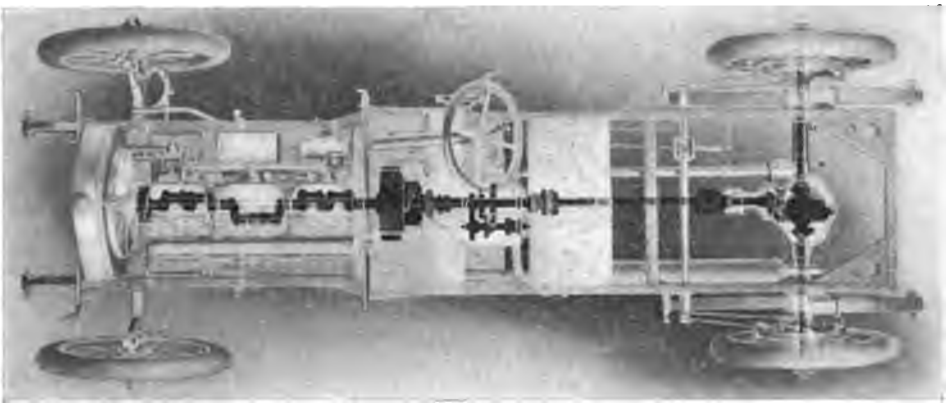


Side view of Chassis of a 40 H. P. Automobile.

19 Clutch pedal
20 Foot brake pedal
21 Gear shift lever
24 Emergency brake lever
32 Grease cups
A Steering gear adjustable nut and counter collar
G Steering gear oil plug
H Steering gear bell crank
I Steering gear bell crank shaft
J Radius rod
K Fore and aft steering rod

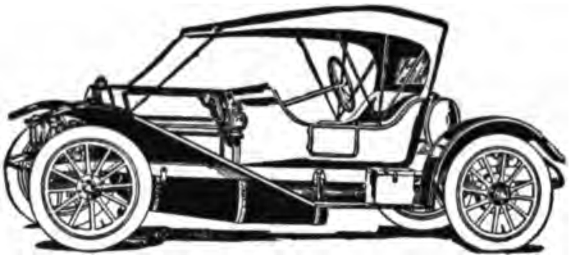
A Study of the Photographs of the Top and Side view of a Modern 4-Cylinder, Shaft Driven Car.

CHART No. 26.

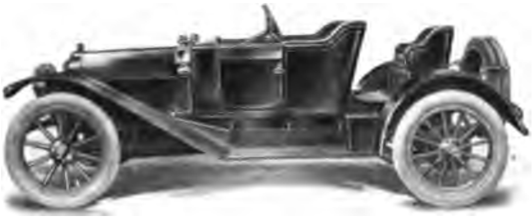


A Phantom of the Model Chassis Showing a Propeller Type Design of Drive Line from Motor to Rear Hubs.

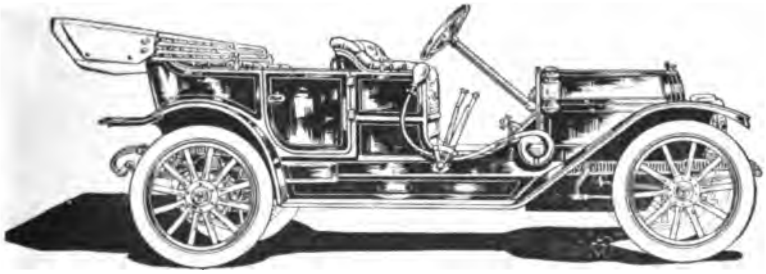
NAMES OF THE VARIOUS TYPES OF CARS.



RUNABOUT

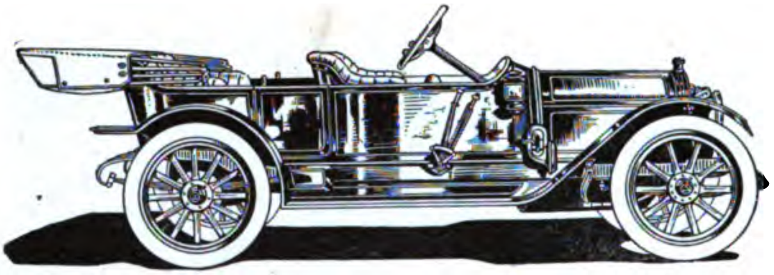


FORE DOOR ROADSTER



MEDIUM SIZE TOURING CAR

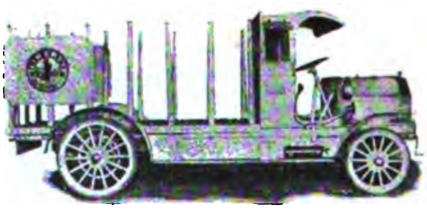
CHART No. 27.



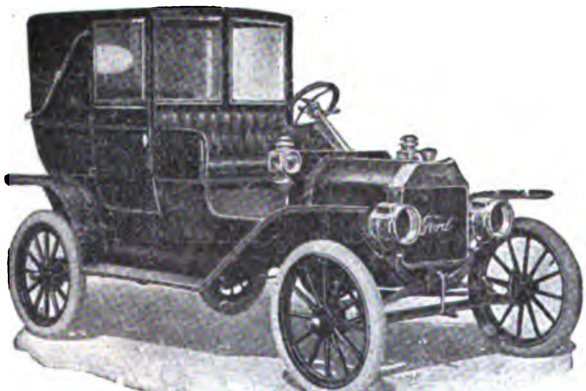
SEVEN PASSENGER TOURING CAR

A MOTOR DELIVERY WAGON

LIMOUSINE.



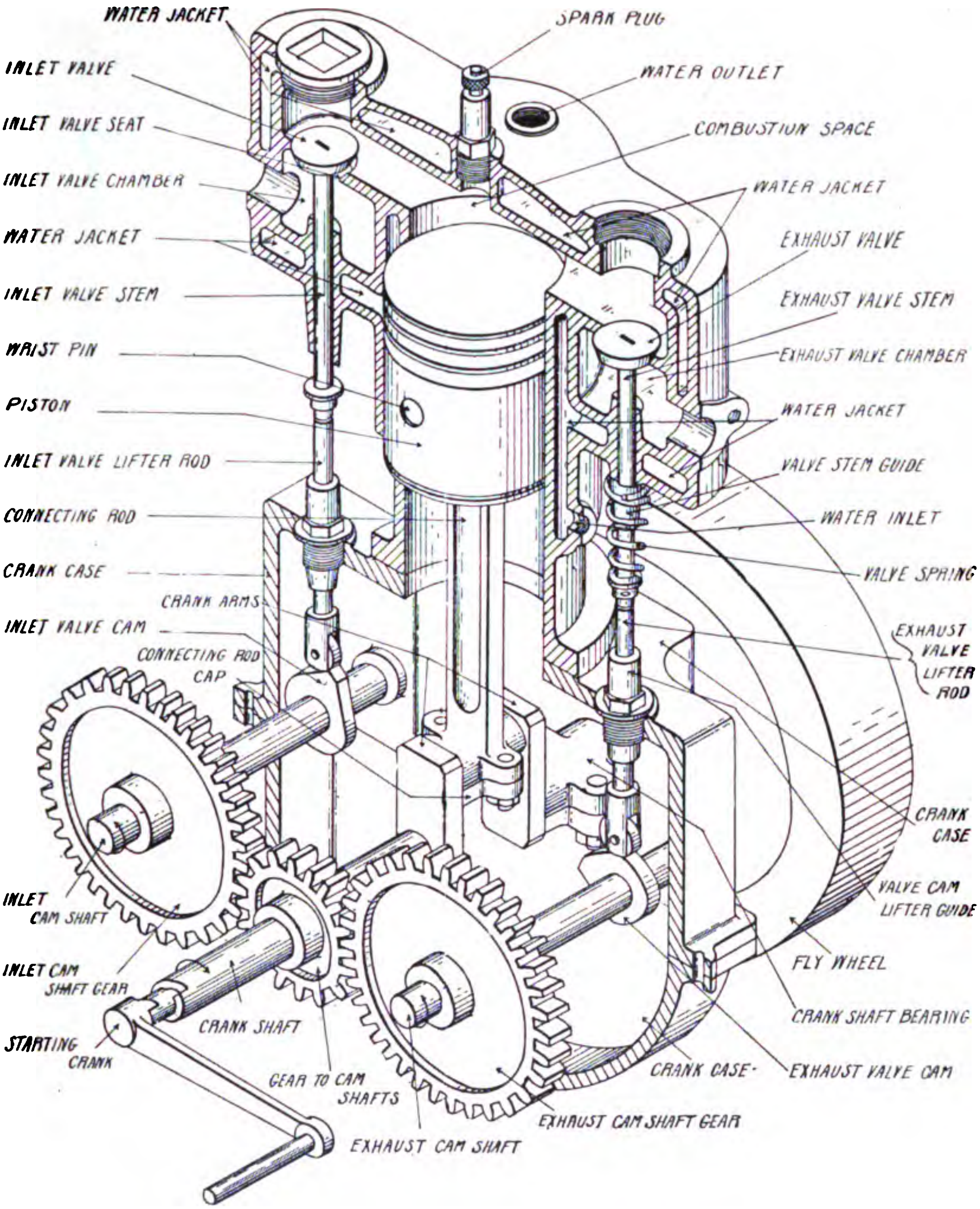
A TRUCK



TOWN CAR, also style used for Taxicab service when fitted with a Taximeter.

ELECTRIC COUPE

CHART No. 28.



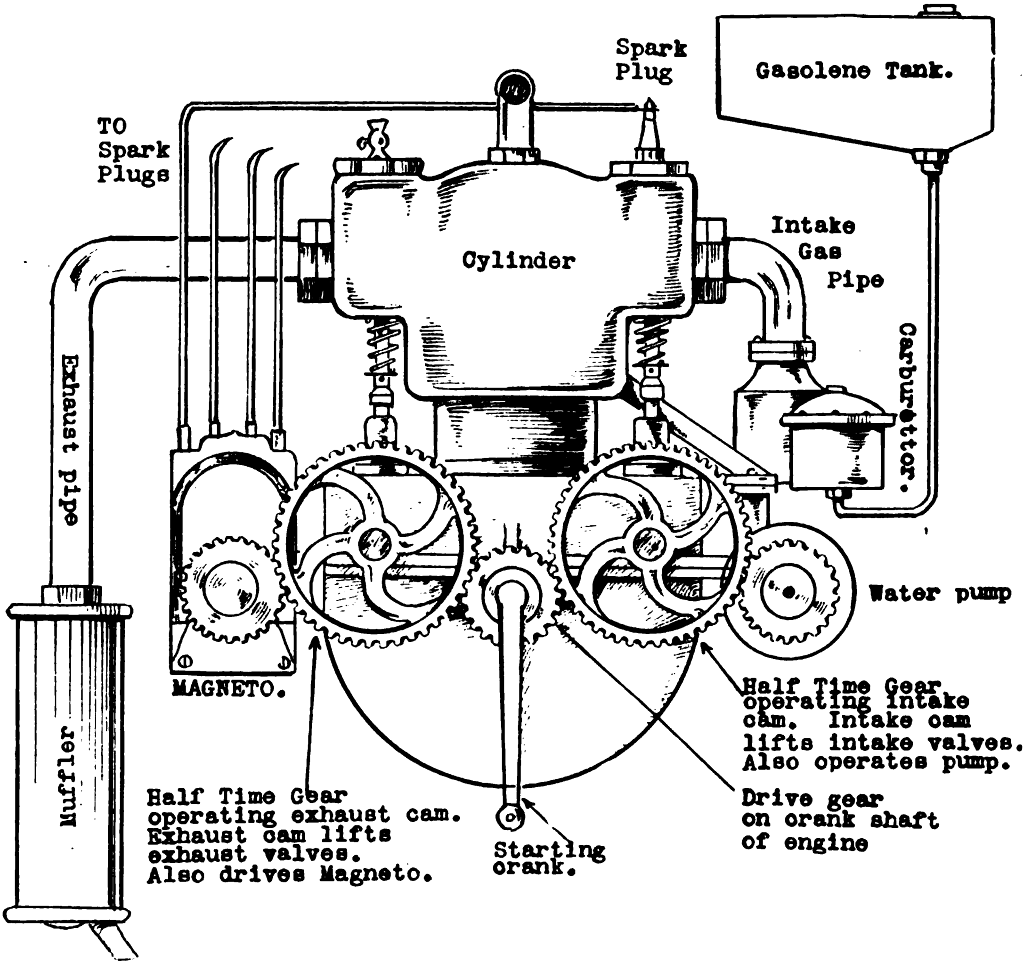
The Four Cycle Gasoline Engine and Its Parts

When in doubt as to the names of any parts of the engine refer to this chart.

The type of valves (both intake and exhaust) on this engine are called "mechanically operated valves."

The type of cylinder is the "T-Head type," with the exhaust valves on one side and the intake valves on the opposite.

CHART No. 29.


TO Spark Plugs
Spark Plug
Gasolene Tank.
Cylinder
Intake Gas Pipe
Carburettor.
Exhaust pipe
Muffler
MAGNETO.
Water pump
Half Time Gear operating intake cam. Intake cam lifts intake valves. Also operates pump.
Half Time Gear operating exhaust cam. Exhaust cam lifts exhaust valves. Also drives Magneto.
Starting crank.
Drive gear on crank shaft of engine

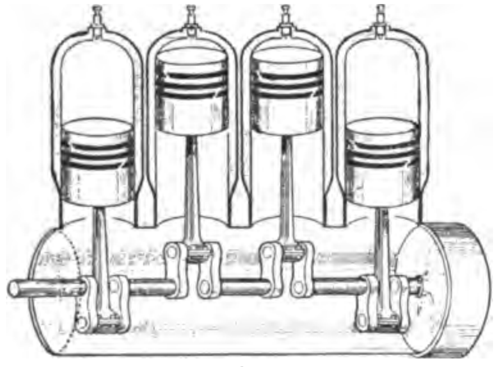
(Fig. 1.)

Front End view of a Gasoline Engine.

This engine, by looking at the end view could be, either a 1-2-3-4-6 or 8 cylinder engine—all we see in this view is the front cylinder

In order to better explain we will turn the engine sidewise (Fig. 2) and we see four cylinders therefore it is a four cylinder engine—the four-cylinder type being the number of cylinders generally used.

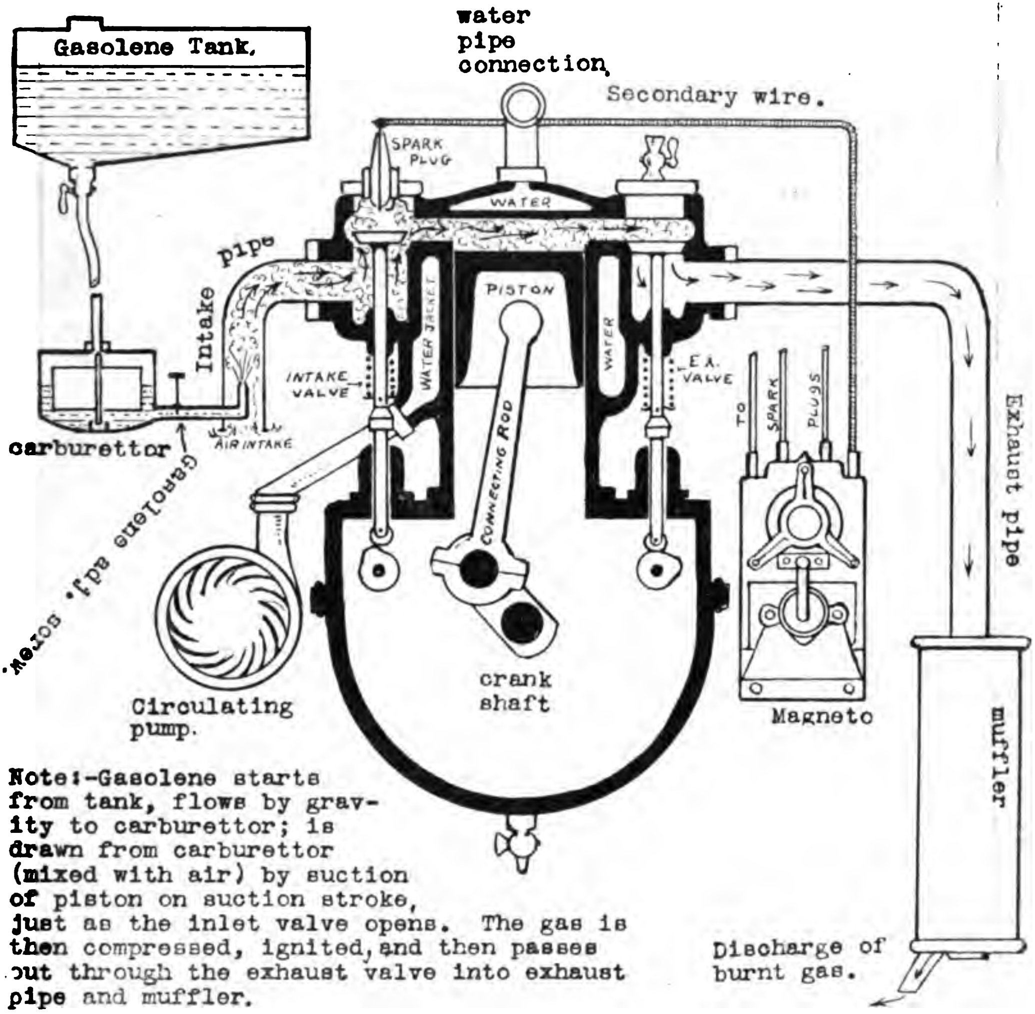
This type of engine above has a "T" head cylinder and the valves are "mechanically" operated.



(Fig. 2.)

Side view of a gasoline engine showing 4 cylinders, pistons, connecting rods and a four-throw crank shaft. The valves and other parts omitted in order to explain the general assembly of the main parts.

CHART No. 30.



Note:-Gasolene starts from tank, flows by gravity to carburettor; is drawn from carburettor (mixed with air) by suction of piston on suction stroke, just as the inlet valve opens. The gas is then compressed, ignited, and then passes out through the exhaust valve into exhaust pipe and muffler.

View of Rear End cylinder of this same four-cylinder Engine cut in half.

In this view we are looking at the drive end or the end of the engine that connects with the transmission.

The object is to illustrate how the gasoline from the tank flows to the carburetor and fills the float chamber until the float needle cuts the gasoline off. The gas, mixed with air, is then drawn into the cylinder by the suction of the piston on the **suction stroke**. During this suction stroke the intake valve must be opened by the cam to permit the gas to enter the cylinder.

After the cylinder is filled with gas, which is the purpose of the **suction stroke**, the intake valve closes and the piston on its up stroke (or **compression stroke**) compresses the gas. At the highest point of compression the gas is ignited by the spark at the point of the spark plugs and the piston is forced down with considerable force; this is called the **explosion stroke**. As the piston travels up again the burnt gas is expelled through the exhaust valve which should open at this time and permit the burnt gas to pass out through the exhaust pipe and muffler, this fourth and last stroke to complete the operation, is called the **exhaust stroke**.

CHART No. 31.

Various Types or Models of Gasoline Engines

They all work on the same principle.

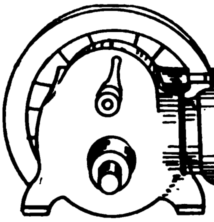


Fig. 1—**A Single Cylinder, Horizontal** type water cooled Gasoline Engine. If the above engine was in a vertical position it would be called a Single Cylinder "vertical" type of engine.

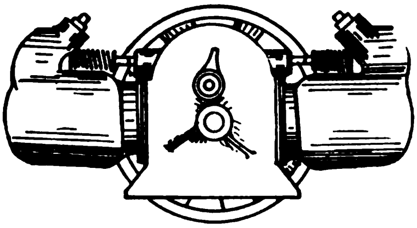


Fig. 2.—**Two Cylinder Opposed Type** of Gasoline Engine. The cylinders are opposite.

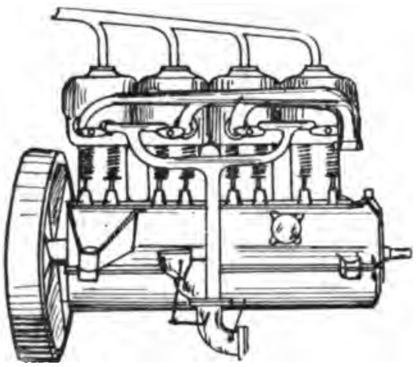


Fig. 3—**A Four Cylinder, Vertical** water cooled Gasoline Engine. Cylinders cast singly. Exhaust and intake valve are all on one side of the engine.

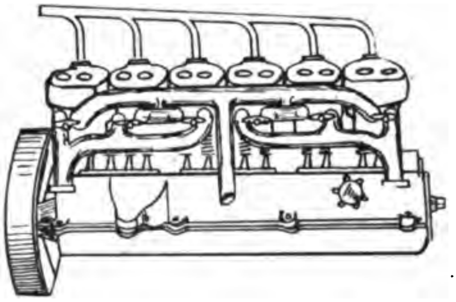


Fig. 4—**A Six Cylinder, Vertical,** water cooled Gasoline Engine. Cylinders cast singly.

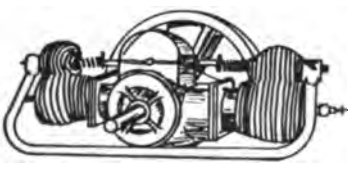


Fig 5—**A Two Cylinder, Opposed Air Cooled** Gasoline Engine.

Any of the above engines can be fitted with any type of ignition.

Single or Multiple Cylinder Engines have but one carburetor.

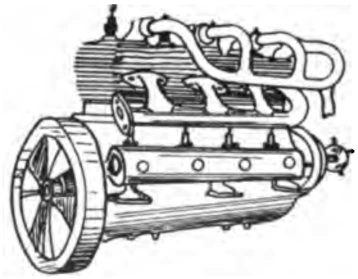


Fig. 6—**A Four Cylinder, Vertical, Air Cooled** Gasoline Engine. Air cooled engine cylinders are usually small. The best method to increase power with air cooled engines is not by increasing the size of the cylinders but have a multiple of small cylinders. This is due to the heat. Larger cylinders are more difficult to cool.

CHART No. 32.

ENGINE

- CYCLE
  - Two Cycle
  - or
  - Four Cycle
- CYLINDER
  - Number of Cylinders
    - 1, 2, 4, 6 or 8 (2, 4 and 6 usual No.)
  - Type of Cylinder
    - "T" Head
    - "L" Head
    - Round Head
      - Cast Singly
      - Cast in Pairs
      - Cast en Bloc
- VALVES
  - Mechanical
    - Intake
    - Exhaust
      - Sometimes in the head of the Cylinder. Sometimes on the side of the cylinder.
  - Automatic
    - Intake only is automatic. Usually placed in the head.
- IGNITION
  - Low Tension
    - "Make and Break" system with Low Tension Magneto or Battery.
  - High Tension
    - High Tension Magneto or
    - High Tension Coil & Batt'y
      - "Dual" or "Double" System.
- FUEL SYSTEM
  - Gasoline
    - How Fed
      - Pressure
      - or
      - Gravity.
- CARBURETION
  - Side Float Carburetor
  - or
  - Center or Ring Float.
- LUBRICATION
  - Gravity or
  - Splash or
  - Pump or
  - Exhaust Pressure or combination of Pressure and Splash.
- COOLING
  - Pump or Forced Circulation with Fan
  - or
  - Thermo-Syphon.

The purpose of this table is to enumerate the various parts necessary to make up an engine.

The different systems employed are also mentioned.

One manufacturer adopts one system for cooling the engine or one system of ignition, while another manufacturer adopts another system.

Both systems are mentioned.

There may be other systems in use but we mention only the ones in general use.

INSTRUCTION No. 7.

THE GASOLINE ENGINE.—General Explanation. Principle of the Gasoline Engine. The Cycle. The Four Cycle. Valves. Cam and Cam Shafts.

GENERAL EXPLANATION OF THE GASOLINE ENGINE.

All Gasoline Engines Work on the Same Principle. It must be a four cycle or a two cycle type. The valve arrangement may be different, but we describe the various types of valves further on in this instruction. The ignition may be different, but we cover all forms of ignition.

We Mention This so that when you see an engine with a different ignition or a different valve arrangement, don't get discouraged, figure it out, because the principle is just the same on all engines.

Gasoline Automobile Engines belong to the class known as INTERNAL COMBUSTION ENGINES.*

This Name Is Used to Distinguish Them From Steam Engines, which are of the EXTERNAL COMBUSTION class, for the heat that a steam engine turns into power is produced away from the engine, under a boiler.

In a Gasoline Engine, the Combustion, or in other words, the burning, of the fuel, takes place inside of the Cylinder of the engine, the fuel being gasoline.

When a Mixture of Gasoline Vapor and Air is Set on Fire, it burns with great rapidity and produces intense heat, which develops the pressure that operates the engine.

This Combustion is so Rapid that it is usually spoken of as an explosion; and that word is often used, although the word combustion is more correct.

The Difference is that an explosion is instantaneous, while the combustion of gasoline vapor and air, although very rapid, is not instantaneous.

The Combustion Takes Place Within the Cylinder of the engine.

One End of the Cylinder is Closed, and the other end is open, the closed end being called the CYLINDER HEAD.

Within the Cylinder is a Piston, sliding back and forth.

The Space Between the Piston and the Cylinder Head is Called the Combustion Space, or COMBUSTION CHAMBER.

The Back-and-Forth Motion of the Piston in the cylinder is called RECIPROCATING MOTION.

In Order That It May Turn the Wheels, this reciprocating motion must be changed to the motion of a wheel revolving on its axle, which is called ROTARY MOTION.

The Reciprocating Motion of the Piston is changed to the rotary motion of the wheels by means of a CRANK SHAFT.

*See Dykes Working Model of a Gasoline Engine.

The Piston is Connected to the Crank Shaft by a Connecting Rod, so that it moves in and out as the crank shaft revolves.

One Complete Turn of the Crank Shaft, by which the piston is moved from one end of the cylinder to the other, and back again, is called a REVOLUTION.

One-Half of a Revolution of the Crank Shaft Moves the Piston from one end of the cylinder to the other, and this is called a Stroke.

It Must Be Remembered that there are TWO STROKES TO EVERY REVOLUTION, one in-stroke and one out-stroke.

A Steam Engine is Called Double Acting, because the pressure of the steam may act on both sides of the piston.

A Gasoline Engine is Called Single Acting, because the pressure acts on only one side of the piston; on the side nearest to the cylinder head.

The Combustion That Causes the Pressure That Operates the Engine takes place between the cylinder head and the piston, in the combustion space.

The Combustion Should Come So that the greatest pressure is exerted when the piston is nearest the cylinder head.

The Pressure Causes the Piston to Slide the Length of the Cylinder, from the head toward the open end.

In a Steam Engine, the pressure of the steam forces the piston to slide first one way and then the other.

In a Gasoline Automobile Engine the pressure from the combustion acts on only one side of the piston, forcing it to slide only one way.

After Being Forced Outward, the piston must be brought inward, again, and this is done by a heavy FLY WHEEL attached to the crank shaft.

FLY WHEEL.

With the Outward Motion of the Piston, the fly wheel starts revolving.

When Once Started, the fly wheel continues to revolve until friction or some other resistance stops it, but before this can happen the pressure is again exerted, keeping it going.

The Fly Wheel Being Attached to the Crank Shaft they revolve together, and because the piston is connected to the crank shaft by the connecting rod it moves with them.

The Piston Moved Outward By the Pressure, starts the crank shaft and fly wheel, and then the fly wheel in continuing to revolve, moves the crank shaft and piston.

Because a Gasoline Engine Does Not Operate With Continuous Pressure, during its action the piston first moves the crank shaft and fly wheel, and then the fly wheel and crank shaft move the piston.

THE CYCLE.

Before There Can Be a Combustion of Mixture in the Cylinder, the mixture must be drawn into the cylinder.

THE FOUR STROKES OR FOUR CYCLE OPERATION. THE FOUR MOVEMENTS BELOW EXPLAIN HOW 2 UP STROKES AND 2 DOWN STROKES COMPLETE THE 4 CYCLE OPERATION

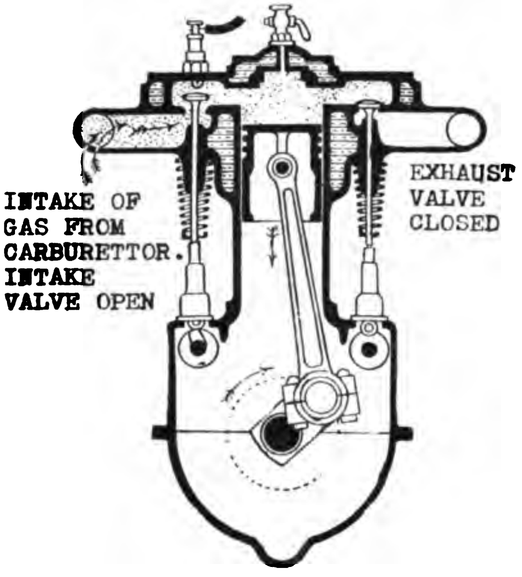


FIG. 1

Admission of the charge (petrol vapour and air. Inlet stroke. (Note inlet valve open.)

1st-STROKE OF PISTON, DOWN, CALLED THE "SUCTION" STROKE.

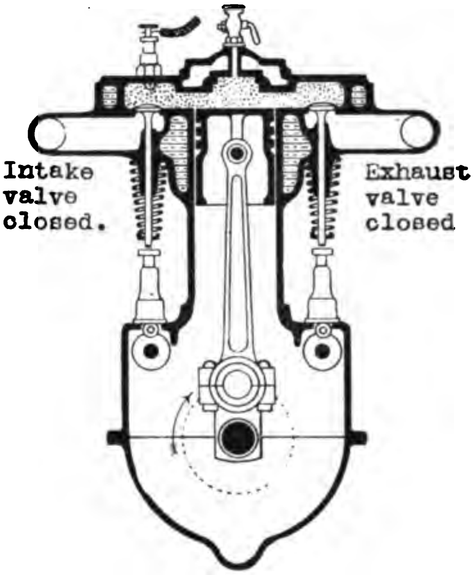


FIG 2.

Charge fully compressed Compression stroke; both valves shut

2nd-STROKE OF PISTON, UP, CALLED THE "COMPRESSION" STROKE

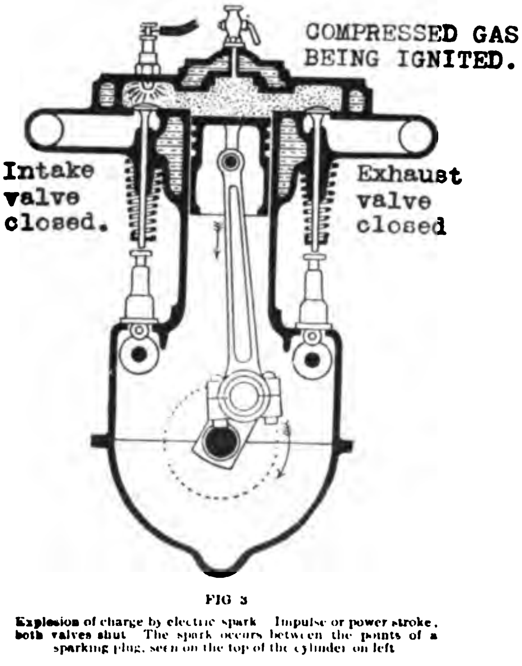


FIG 3

Explosion of charge by electric spark Impulse or power stroke, both valves shut The spark occurs between the points of a sparking plug, seen on the top of the cylinder on left

3rd-STROKE OF PISTON, DOWN AGAIN, CALLED THE "IGNITION" STROKE

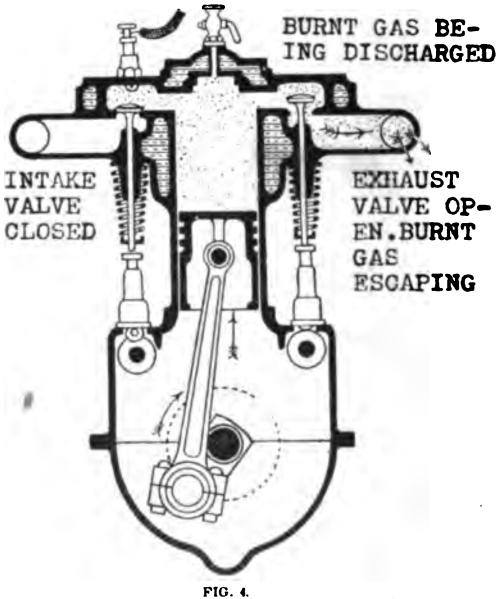

BURNT GAS BEING DISCHARGED
INTAKE VALVE CLOSED
EXHAUST VALVE OPEN. BURNT GAS ESCAPING

FIG. 4.

Expulsion of burnt charge Exhausting stroke, exhaust valve open.

4th-STROKE OF PISTON, UP AGAIN, CALLED THE "EXHAUST" STROKE

Explanation of the Four Cycle or four strokes of a gasoline engine. **This Chart differs from Chart No. 34** in that both valves are mechanically operated. If the reader will refer to the working model of the engine and compare it with this chart the explanation will be doubly simplified.

CHART No. 33.

When in the Cylinder, the Mixture Must Be Prepared, so that it burns with the greatest possible rapidity and heat.

After the Mixture Has Been Burned, the Useless Gases Must Be Removed from the cylinder, to make room for a fresh charge of the mixture.

These Successive Events Must Occur in Their Proper Order, for if any one of them fails, or it is not performed properly, the following event cannot occur, and the engine will stop running.

These Events are called a CYCLE.

The Cycle is Thus Composed of: 1st, the drawing into the cylinder of the mixture 2d, the compression of the mixture; 3d, the burning or ignition of the mixture and, the forcing downward of the piston by the pressure produced by the burning of the mixture; 4th, the removal of the burned and useless gases left after the combustion.

The Cycle is Performed During Two Revolutions of the Crank Shaft, or, what is the same thing, FOUR STROKES OF THE PISTON. (See Chart No. 33.)

The First Event Occurs while the piston makes a downward stroke, during which the cylinder is sucked full of the mixture, just as a similar stroke of a pump or syringe sucks in a liquid.

This is Called the Inlet Stroke, or SUCTION STROKE.

The Next Stroke of the Piston is an Upward Stroke, during which the mixture sucked into the cylinder is prepared by being compressed, and it is then set on fire, or ignited.

This is Called the COMPRESSION STROKE.

When the Compressed Gas is Ignited the Pressure from the Combustion forces the piston to make a downward stroke.

This is Called the POWER STROKE.

The Next Inward Movement of the Piston Pushes the Burned and Useless Gases Out of the cylinder.

This is Called the EXHAUST STROKE.

Valves are Arranged to Open and Close at the Proper Times to admit fresh gas and to let out the burned gas, and the positions of the piston and valves for each function are shown on Chart 33.

In the Diagrams the piston is at the beginning of the stroke and the arrows show the direction in which it is moving.

The Fly Wheel Receives an Impulse During the Power Stroke, and it keeps revolving while the piston is moved through the exhaust, inlet and compression strokes.

During These Three Strokes the Engine is Not Developing Power.

The Fly Wheel Being Heavy, and revolving rapidly ,it furnishes the power for the driving mechanism during the three strokes when the piston is accomplishing the exhaust, inlet and compression strokes that are necessary before there can be another power stroke.

THE FOUR CYCLE OR THE FOUR STROKE.

As Explained Previously, Four Events ,Called the Cycle, Occur in the Cylinder of a Gasoline Engine During Every Two Revolutions, or, what is the same thing, during every four strokes.

The Strokes of the Piston During the Events of the Cycle Occur are called the;

1st—INLET STROKE.
2d—COMPRESSION STROKE.
3d—POWER STROKE.
4th—EXHAUST STROKE.

These will be described in their proper order.

INLET STROKE.

The Inlet Stroke is an Outward Stroke of the Piston that sucks the cylinder full of the explosive mixture (See Chart No. 33, Fig. 1—also see Dykes working model of the engine.)

In Order That the Engine May Deliver Its Full Power, it is necessary that all of the mixture possible may be sucked in, for it is clear that if the cylinder is only partly filled not as much power will be developed as would result from a full charge.

There Must Be No Obstruction in the Inlet Pipe to prevent the mixture from entering the cylinder easily, and the inlet valve must open widely enough to admit the full charge.

If the Inlet Valve is Mechanically Operated (which is shown in Chart 33) the spring must be adjusted so that it opens promptly as soon as the sucking action commences, remains wide open during the stroke, and closes quickly as soon as the pressure in the cylinder becomes equal to the outside pressure of the atmosphere.

If All the Openings Into the Cylinder; the exhaust valve, the spark plug, piston rings, relief cock, etc., are not tight ,air or gas will be sucked into the cylinder through them at the same time that the charge enters through the inlet valve, and this would destroy the proportions of the mixture.

If the Inlet Valve Does Not Open Soon Enough, the piston will have made part of its stroke before the charge begins to enter; if it opens too soon, part of the burned gas from the previous power stroke will be pushed into the carburetter.

If It Closes Too Soon, the cylinder will not get a full charge; if it closes too late, part of the mixture will be pushed out of the cylinder on the compression stroke.

COMPRESSION STROKE.

The Cylinder is Filled With the Mixture During the Suction Stroke. The next stroke up of the piston is the compression stroke. As the mixture cannot escape, it is compressed until it occupies a much smaller space. (See Chart 33, Fig. 2.)

POWER OR EXPLOSION STROKE.

At This Instant the Spark Should Occur. (See Fig. 3, Chart 33.)

Too Poor or Too Rich a Mixture Will Not Burn as Rapidly as a proper mixture, and must therefore be ignited sooner.

In Getting the Proper Time for the Ignition of the Mixture, it must be remembered that it is necessary for the spark to pass at such a time that all of the mixture is to be burned just as the piston is at the top of its stroke.

The Timer in the Ignition Circuit is so Arranged (See Chart explaining a timer) that it may be moved in order that the spark may pass in the cylinder at the instant desired by the driver.

Advancing the Spark is to move the timer so that the spark will ignite the mixture BEFORE the piston reaches it upmost point in the cylinder.

Retarding the Spark is to move the timer so that the spark occurs later in the stroke, in some cases as the piston reaches its upmost position, or even a trifle after.

If the Spark is Advanced Too Much, all of the mixture will have been burned before the piston reaches its upmost point, so that it will be necessary for the fly wheel to force the piston upward against the pressure until it gets to its upmost point.

This Strains the Engine, and causes a sound that is called a GAS KNOCK; a hard, metallic sound that may be prevented by retarding the spark.

It is Seen From the Foregoing that the speed of the engine may be controlled by advancing or retarding the spark, the speed of the car changing accordingly.

EXHAUST STROKE.

During the Exhaust Stroke, the Cylinder is Cleared of the Burned and Useless Gases that are left from the power stroke. (See Chart 33, Fig. 4.)

Toward the End of the Power Stroke, there is still pressure in the cylinder, and when the exhaust valve is opened this pressure will cause the gases to begin to escape.

As the Exhaust Stroke is an Upward Stroke of the Piston, the piston will push out through the exhaust valve all of the burned gases that do not escape by their own pressure.

Back Pressure, caused by the muffler or obstructions in the exhaust pipe, will prevent the burned gases from escaping as freely as they otherwise would, and all may not be pushed out by the time that the exhaust valve closes.

If all the Burned Gases are Not Pushed out of the Cylinder, it will prevent a full charge of fresh gas from being drawn in, which will cause a weak explosion.

The Exhaust Valve Closes as the Piston Reaches Its Upmost Point, or a little after it, the inlet valve opening as it closes.

The Exhaust Valve and Its Seat are Exposed to the Full Heat and Flame of the Burning Mixture, and are more liable to warp or pit than the inlet valve.

It Must Be Watched, and if there does not seem to be perfect compression when the engine is cranked the probability is that it needs grinding.

A Proper Mixture Will Be Entirely Burned before the exhaust valve opens.

An Improper Mixture That Burns Slowly, may still be burning when the exhaust valve opens, and will heat the exhaust pipe and muffler ,so that the pipe may become red hot.

Explanation of the 4 Strokes or 4 Cycle Operation of a Gasoline Engine with an AUTOMATIC Intake Valve.

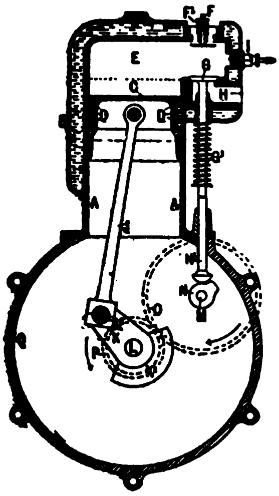


Fig. 1.

SUCTION STROKE
Inlet valve open.
A A, cylinder walls
B, water jacket
C, piston
D D piston rings
E, compression space
F, inlet valve

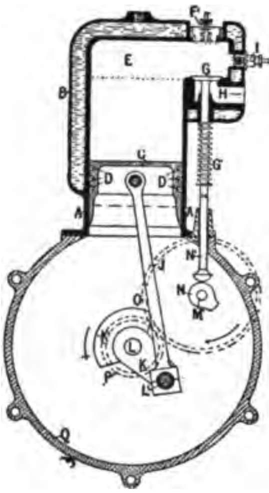


Fig. 2.

COMPRESSION STROKE.
Both valves closed.
F1, inlet valve spring
G, exhaust valve
G1, exhaust valve spring
H, exhaust outlet
I, sparking plug

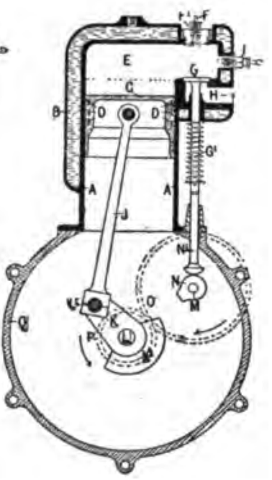


Fig. 3.

POWER OR EXPANSION STROKE.
Firing of Mixture.
J, connecting rod
K, crank check
K1, crank balance weight
L, crankshaft
L1, crank pin
M, half-time shaft

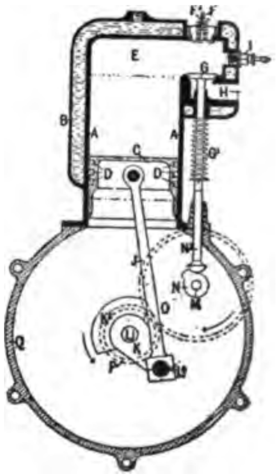


Fig. 4.

EXHAUST STROKE
Exhaust valve open.
N, exhaust valve cam
N1, exhaust valve tappet
O, half time shaft gear wheel
P, crank shaft gear wheel to operate O
Q, crank case

Note—The engine as represented on the Working Model of the Engine and illustrated in Charts 29 and 33 is different from the above engine in that the Engine on the Working Model has **Mechanical Inlet and Exhaust Valves.** The above engine has **Automatic Inlet Valve**—"F" but **Mechanically** operated Exhaust Valve.

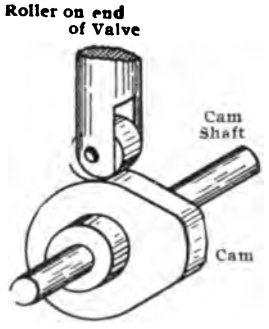


Fig. 5.

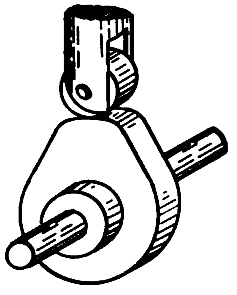


Fig. 6. Cam "nose" raising valve.

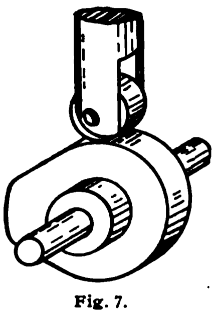


Fig. 7.

View of Cam in 3 Positions.

The Cam Shaft passes through the upper part of the Crank Case of the Engine and is driven by inlet Cam shaft gear and exhaust Cam shaft gear, called the half time gears. See Chart 29 (the intake as well as the exhaust valves are mechanically operated in Chart 29).

The Cam Raises the Exhaust Valve at the proper time to permit the burnt gas to escape. The Automatic Valve above is opened by the suction of the piston and admits fresh gas. This Automatic Inlet Valve is opened during the Suction stroke but it does not open on any other stroke.

It Would Appear however to open in the explosion stroke because the piston is on a "down" stroke but this is not the case, because the force or pressure of the explosion occurring at this time, tends to keep the Automatic Valve F closed against its seat.

CHART No. 34.

Such a Mixture Wastes Fuel, and may result in fire.

It May Be Corrected by making a correct adjustment of the carburetter and spark.

VALVES.

The Engine Has Two Valves to Each Cylinder, an Inlet Valve and **an Exhaust Valve.** (See Chart 29, and study the names of the parts carefully.)

The Inlet Valve Admits Fresh Gas to the cylinder.

The Exhaust Valve Permits the Burned and Useless Gas to Escape after the power stroke.

As Fresh Gas is Going Into the Cylinder During Only One Stroke of Every Four, the inlet valve is opened during only one stroke of every four, or in other words, during one stroke of every two revolutions.

The Exhaust Valve is Opened and Held Open by a mechanism connected with the engine.

This is Called Being Mechanically Operated.

Mechanically Operated Valves are opened and held open by means of cams (See Chart 29—both "intake" and "exhaust" valves are mechanically operated.)

Exhaust Valves are Always Mechanically Operated.

Inlet Valves are Sometimes Mechanically Operated, and sometimes they are AUTOMATIC. (See Chart 34 for automatic intake valve.)

It Must Be Understood that the valves of a gasoline engine always open INWARD.

Thus the Pressure from the power and compression strokes tends to keep them firmly on their seats.

***An Automatic Valve** is held against its seat by a light spring (See Chart 34, Fig. 1.) **During the Suction Stroke,** the sucking action of the piston as it slides outward in the cylinder, draws the valve open.

At the End of the Suction Stroke, when the suction ceases, the spring draws the valve disc back to its seat, and the gas is prevented from escaping through the valve.

Detailed description of Automatic Valves on Chart No. 34.

.CAMS AND CAM SHAFT.

A Cam is a device that produces intermittent motion. (See Chart 34.)

When an Object is in Motion part of the time, and at rest between motions, its action is said to be INTERMITTENT.

A Cam May Best Be Described as a wheel with a hump on one side, or in other words, it is a piece of metal revolving with a shaft, one part of it being farther from the shaft than the rest.

The Part of the Cam That Projects is caleld the **Nose.**

Anything Resting Against the Cam will be moved as the Nose, in turning, touches it.

---

*The Automatic Intake Valve is now seldom used—we merely show this type in order that the reader will note the difference between the "Automatic" Intake Valve and the "Mechanically Operated" Intake Valve. The "Mechanically" operated Intake Valve is the one generally used, as shown in Chart 29-30-31-33.

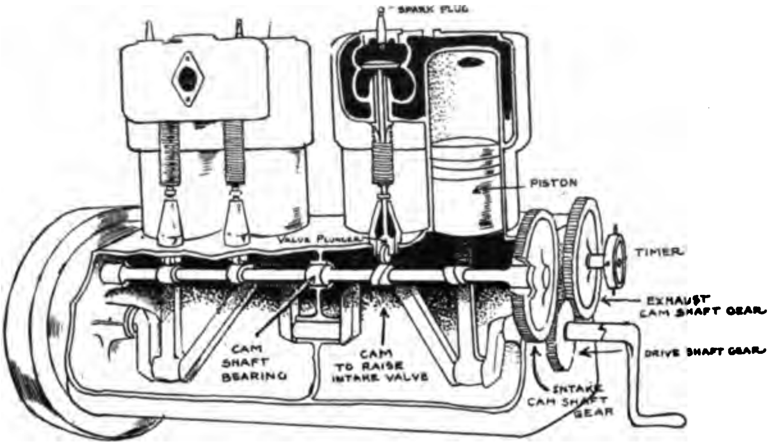


Fig. 1.—Side view of a Four Cylinder Engine with several parts omitted in order to clearly explain how the "Cam Shaft" and "Cams" operate.

On the above Engine we have the "Mechanical Type" of Valves, with cylinders cast in pairs (two Cylinders cast together).

The Intake Valves are on one side of the Engine (as shown), and the Exhaust Valves are on the opposite side.

There are two "Cam Shafts" running through the inside of the top part of crank case of the Engine on its own bearings.

The Intake Cam Shaft (shown above), is operated by a "Cam Shaft Gear" which is driven by the "Drive Gear" on the crank shaft.

The Exhaust Cam Shaft (not illustrated) is on the opposite side of the Engine and is operated by the "Exhaust Cam Shaft Gear" in the same manner as the Intake Cam Shaft. (See Charts 29 and 30 to get the idea as shown from the end view).

When the Engine crank shaft is started in motion by turning the starting crank the drive gear on the crank shaft (one-half the diameter of the cam gears) being in mesh with the cam gears, the cam gears start turning the cam shaft. The "Cams" placed at the exact position on the shaft, will raise the valves when the "nose" of the cam is in the right position as will be seen by studying the illustration.

There is nothing complicated in this, but a great deal depends on just when this cam must raise the valve. If the cam raises the valve too early or too late—simply change same by meshing the gears properly.

A study and manipulation of Dyke's working model of the Engine will make this clear.

Chart 34 Shows a Cam in Three Positions of a Revolution, with the end of a VALVE STEM, which is a rod attached to a valve disc, resting against it.

The End of the Valve Stem Carries a Small Roller to reduce friction.

As the Cam Turns, the nose comes in contact with the roller.

The Valve Stem Being Held in Guides, it cannot move in any direction but up and down.

When the Nose of the Cam Comes in Contact With the Roller, it pushes the valve stem upward. (See Chart 35.)

As the Valve Stem and Valve Disc are in One Piece, this opens the valve.

While the Flat End of the Nose of the Cam is Under the Roller the valve is held open.

When the Nose Passes From Under the Roller, a spring draws the valve stem down again, closing the valve.

Thus the Steady Rotary Motion of the Cam is Changed to the intermittent motion of the valve.

Note—**A Valve Lifter Rod** is usually placed between the cam and the valve stem, for reasons that will be explained further on.

Cams are Attached to Cam Shafts, and for strength, they are often made in one piece.

The Cam Shaft Has a Cog Wheel, or GEAR, on one end.

This Cam Shaft Gear Connects, or Meshes, with a gear on the crank shaft.

When the Crank Shaft Revolves, these gears force the cam shaft to revolve also.

As Has Been Shown, the valves open only once while the crank shaft makes two revolutions.

Therefore the Cam Shaft Should Revolve Only Once while the crank shaft revolves twice.

If the **Two Gears Running Together,** or in other words, IN MESH, have the same number of teeth ,they will make the same number of revolutions.

If One Gear Has Twice as Many Teeth as the other, it will revolve only ONCE while the other revolves TWICE.

This is Called a Two-to-One Gear. (See Charts No. 29, 30 and 35.)

Because the Cam Shaft Must Revolve only once while the crank shaft revolves twice, the cam shaft gear has twice as many teeth as the crank shaft gear.

The Cam Shaft is Also Called the Secondary Shaft, or HALF-TIME SHAFT.

CYLINDERS.

The Cylinder of a Gasoline Engine is Made of Cast Iron, and the water jackets are generally cast in one piece with it.

In Some Designs, notably the Pope-Toledo and Cadillac, the water jackets are formed by surrounding the upper part of the cylinder with sheet copper.

The Cylinder of an Engine With More Than One Cylinder, are either cast singly, or in pairs; that is, two cylinder with their water jackets are made in one piece. (See Chart 35.)

The Portion of the Cylinder in Which the Piston Moves should be a true circle, and as smooth as possible.

In the Better Grade of Cars the Cylinder Walls are Ground to a Smooth Finish so that there may be as little friction as possible.

Any Roughness of the Walls Will Cause Wear, which comes in the form of cuts and scratches lengthways, that permit the pressure to escape around the piston.

CRANK CASE.

The Cylinder is Attached at Its Open End to the Crank Case, which forms a box around the crank shaft.

The Crank Case is of Irregular Shape, so that while there is plenty of room for the cranks and connecting rod to revolve, there is little waste space.

It Contains the Crank Shaft Bearings, and forms the bed-plates or foundation, for the engine. (See Chart 29.)

It is Often Made in Two Parts, an upper part, bolted to the cylinder and containing the crank shaft bearings, and a lower part enclosing the crank shaft.

As the Crank Shaft Case is Intended to Contain Lubricating Oil, it is tight so that there may be no leakage.

There are Often Hand Holes in It through which adjustment and examinations may be made without dismounting the engine.

The Crank Case is Usually Made of Aluminum Alloy, or if in two pieces, the upper may be made of bronze, and the lower of aluminum.

The Crank Case is Used to Support Various Parts of the mechanism, like the pump, magneto, etc.

CARBURETION.

Pure Gasoline Vapor Will Not Burn, but must be mixed with air before it can be used to develop pressure.

The Mixing of Gasoline Vapor and air in the proper proportions is called carburettion.

To Give the Best Results, the mixture of gasoline vapor and air must always be in correct proportion.

The Device that accomplishes this is called the Carburetor.

The Carburetor is Connected to the Inlet Valve Chamber by the Inlet Pipe, and the gasoline flows to it from the supply tank through a small pipe, called the FEED PIPE. (See Chart 31.)

There is a Passage Through the Carburetor into which the air is drawn as the piston makes the suction stroke.

The Liquid Flows to the Carburetor, and is brought into contact with the current of air.

The Gasoline Turns to Vapor, and is Absorbed by the air, the mixture being sucked into the cylinder on the suction stroke.

The Quantity of Mixture that is sucked into the cylinder during one suction stroke is called the CHARGE.

Details of carburettion in Instruction further on.

IGNITION.

The Charge is Set on Fire, or Ignited, at the Proper Time by an electric spark.

The Current of Electricity That Supplies the Spark is produced by a BATTERY, or by a MAGNETO or DYNAMO, driven by the engine.

The Exact Instant for the Ignition of the Charge depends on the kind of work to be done, the speed of the engine ,and the quality of the mixture.

If the Charge is Ignited Too Soon or Too Late, the engine will not run properly.

The Time of Ignition, or instant when the electric spark sets fire to the charge is controlled by means of **a** COMMUTATOR or TIMER.

The driver adjusts the timer by a lever on the steering column.

(Details of ignition further on.)

COOLING.

The Explosion of the Charge in the cylinder produces heat.

This Heat is so Intense that the lubricating oil will burn and be made useless if the cylinder is not kept fairly cool.

If the Lubricating Oil Were Burned, the friction of the piston against the cylinder walls would be so great that they would cut each other, and the piston would stick, stopping the engine.

The Cylinder Must Therefore Be Kept From Heating to the point at which the lubricating oil would burn, but as the heat develops the pressure, the cylinder must not be too cool.

The Cylinder May Be Cooled either by a current of air ,or by water circulating around it.

In an Air Cooled Engine, the outside of the cylinder is covered with points or projections.

The Heat Within Heats These Projections, and a fan blows a current of air against them.

The Air Cools the Projections, which keeps the cylinder cool.

In a Water Cooled Engine, the upper part of the cylinder is surrounded by channels, called WATER JACKETS, through which the water flows.

The Water is Kept in Circulation either by a pump, or by its own action, as will be explained further on.

In Flowing Through the Water Jackets, the water absorbs some of the heat, and becomes heated itself.

The Water is Then Passed Through Pipes exposed to the air, and is cooled.

The Exposed Pipes Form the Radiator, or WATER COOLER

After Being Cooled in the Radiator, the water again passes through the water jackets.

In This Manner the Cylinder is kept from becoming too hot.

THE PUMP.

The Pump of the Water Circulation System, the cooling fan, the mechanical lubricator, the magneto or dynamo, are driven by the engine, and are connected to it by gears or belt.

MUFFLER.

If the Exhaust Valve Opened directly into the air, the noise of the explosions would be like the firing of a gun.

This is Because the Pressure in the Cylinder is Much Higher Than the Pressure of the Air, and a sudden change from one to the other would produce a loud report.

The More Sudden the Change, and the greater the difference in the pressure, the sharper would be the noise.

The Pressure Must be Reduced Before the Gas Escapes into the air, in order to reduce the noise.

The Exhaust Valve is therefore connected, by means of the EXHAUST PIPE, to the MUFFLER or SILENCER. (See Charts 30 and 31.)

The Muffler Reduces the Pressure of the Gas, and the gas escapes from it slowly at the pressure of the air, making no noise.

The Piston of a Steam Engine begins to move as soon as the steam is admitted to the cylinder.

This is Because pressure already exists in the boiler.

A Steam Engine is therefore SELF STARTING.

There is No Pressure to Operate a Gasoline Engine until the engine is running, as the combustion must take place in the cylinder before pressure is generated.

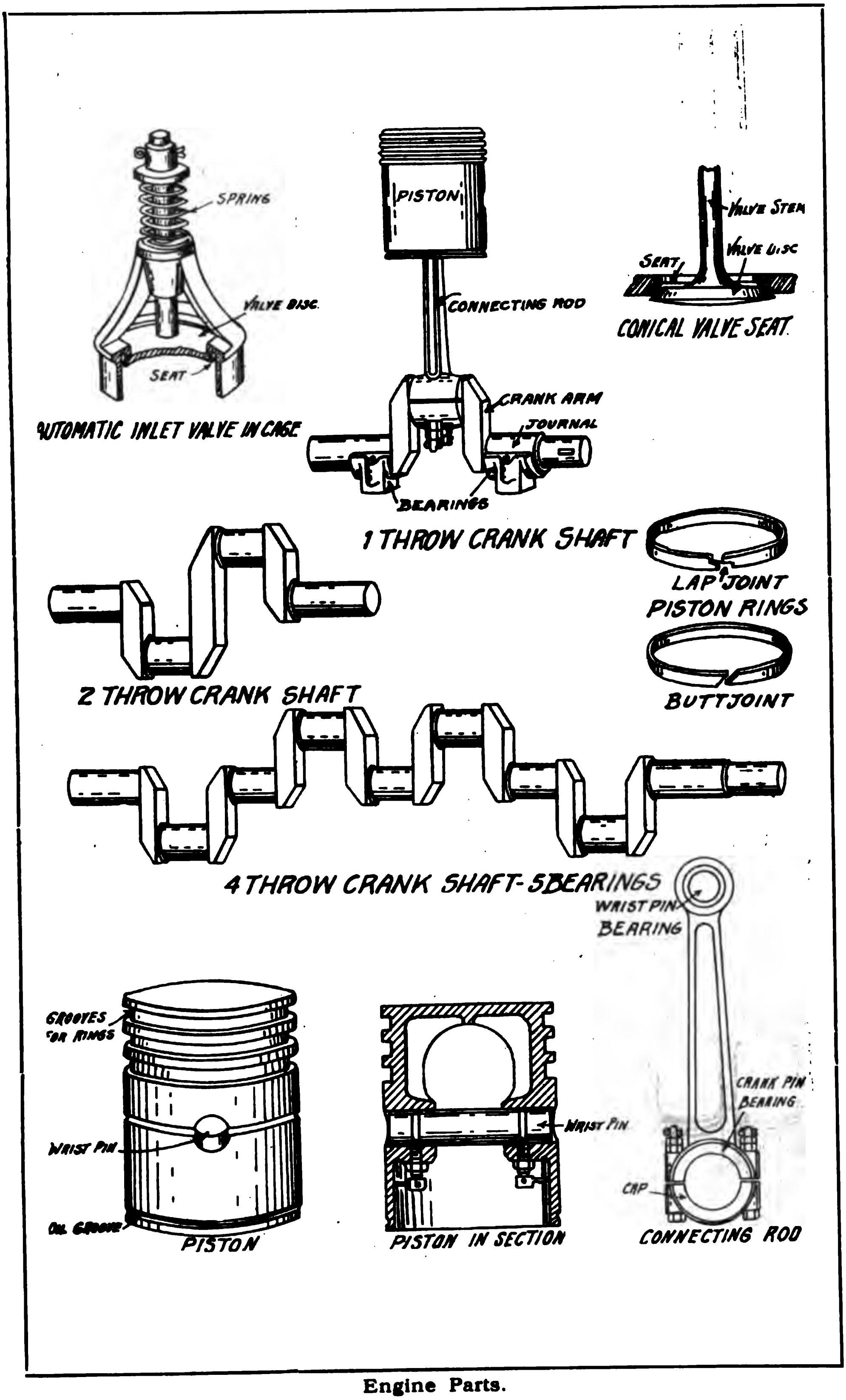
A Gasoline Engine is therefore not self starting.

The Crank Shaft Must Be Turned by Hand, or by some outside power, until the piston has made the suction and compression strokes.

The Engine Begins to Operate when ignition has occurred.

The Crank Shaft is Revolved to make the piston go through the necessary strokes by means of a STARTING CRANK, which may be permanently attached, or separate, to be carried in the tool box.

*Self-starting devices or means for cranking the engine from the seat is now being advertised.



Engine Parts.

CHART No. 36.

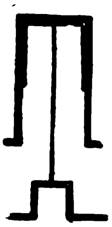


Fig. 1.

One Cylinder Engine with crank shaft set at 360 degrees.

Crank shafts on one cylinder Engines are "counter-balanced" with weights on the side of the crank shaft.

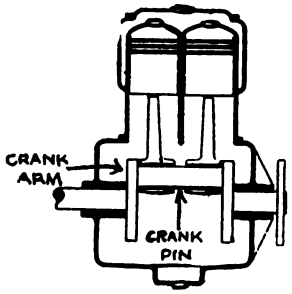


Fig. 2.

**Two Cylinder Vertical Engine.
Crank shafts set 360 degrees.
"Counter balanced" crank.**

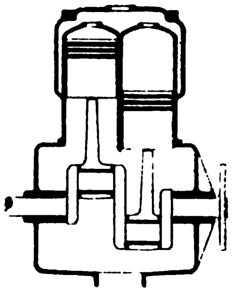


Fig. 3.

**Two Cylinder Vertical Engine.
Crank Shaft 180 degrees.**

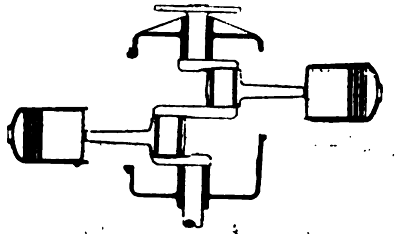


Fig. 4.

**Two Cylinder opposed type of Engine.
Crank shaft set 180 degrees.
Mechanically balanced shaft.**

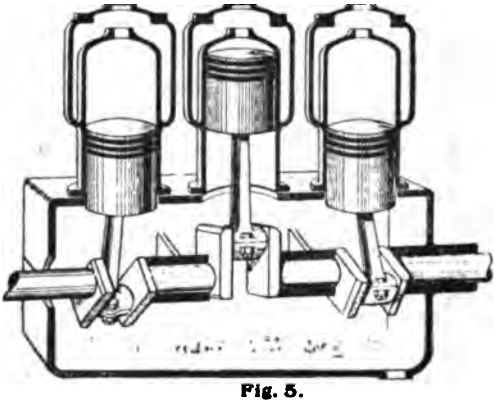


Fig. 5.

**A Three Cylinder Engine.
Crank shaft 120 degrees.**

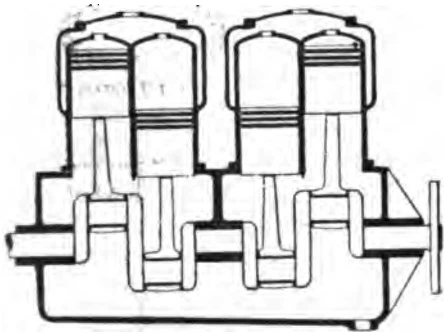


Fig 6.

**Four Cylinder engine.
Crank shaft set 180 degrees.**

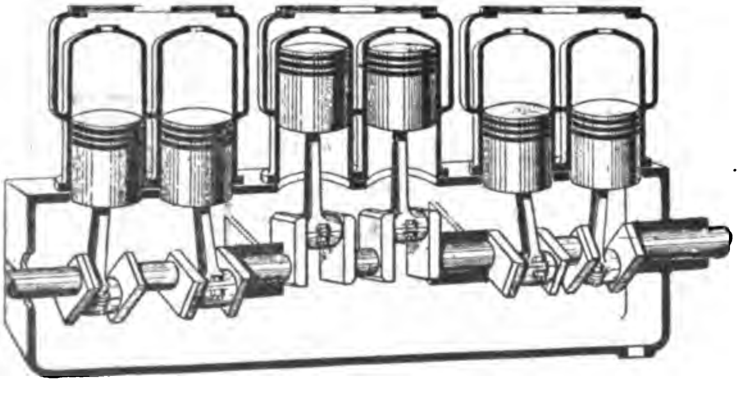


Fig. 7.—A Six Cylinder Engine consists of two Engines, each of three cylinders, coupled together. The center cranks and each consecutive pair being in the same plane. The cranks (viewed from each end) are set 120 degrees relative to each other, except the third and fourth.

Crank Shafts.

CHART No. 37.

INSTRUCTION No. 8.

ENGINE PARTS.—Crank Shaft. Connecting Rod and Wrist Pin. Piston and Piston Rings. Mechanically Operated Valves. Automatic Valves. Inlet Pipe. Exhaust Pipe. Spark Plugs. Timer. Speed Control. Govener of Engine.

THE CRANK SHAFT.

The Crank Shaft changes the reciprocating motion of the piston to the rotary motion necessary to turn the wheels.

It Rests in Bearings that hold it in a fixed position, but permit it to revolve.

The Crank Must Be Rigidly Attached to the Crank Shaft, and to secure this rigidity they are usually made in one piece.

The Crank Projects From the Crank Shaft, and when the shaft revolves the crank makes circles around it.

A Crank is one of the most common of mechanical devices.

A Windlass is Turned With a Crank; a bucket or chained pump is operated with a crank; the pedals of a bicycle from cranks.

In a Bicycle, the crank arms are attached at their inner end to the crank shaft, and to their outer ends the pedals are attached.

When Riding a Bicycle, the feet press on the pedals at the ends of the crank arms, and make the crank shaft revolve.

The Feet describe circles around the crank shaft.

Each Crank Arm and Pedal Form a Crank, and there is only one arm to a crank.

In a gasoline Engine, one crank arm to each crank would not be strong enough, and there are therefore two arms to each crank. (Fig. 2, Chart 37.)

The Outer Ends of the Crank Arms are connected by the CRANK PIN.

The Crank Pin corresponds to the pedal of a bicycle. (Fig. 2 Chart 37.)

For Stiffness and Strength, the crank shaft bearings must be as close together as possible.

A Gasoline Engine Has as Many Cranks as it has cylinders.

The Position of a Crank on a Crank Shaft in relation to other cranks on the same shaft is expressed in degrees of a circle.

If a Crank Shaft has Two Cranks Projecting in Opposite Directions, it is called a 180 degree crank shaft. (See Fig. 304, Chart 37.)

If the Two Cranks Project From the Same Side of the Shaft, so that the crank pins are in line, it is called a 360 degree crank shaft. (See Fig. 1 and 2, Chart 37.)

In Such a Case, instead of having two pairs of crank arms, with a crank pin to each pair, the crank pin may be made long enough to hold both connecting rods, and has only one pair of crank arms. (Fig. 2, Chart 37.)

If There are Three Cranks, one-third of a revolution apart, it is called a 120 degree crank shaft. (Fig. 5, Chart 37.)

A Crank Shaft With One Crank is called a ONE THROW crank shaft. (Fig. 1, Chart 37 and Chart 36.)

A Crank Shaft has as Many Throws as it has pairs of crank arms.

One, Two and Four Throw crank shafts are shown in Chart 36.

BEARINGS.

The Bearings of a Crank Shaft are usually BUSHINGS of bronze or other metal that does not wear rapidly.

A Bushing is a Short Piece of Pipe or Tube, fitting the shaft snugly. (Chart 36.)

These Bearings are Split Lengthways Into Two Parts, one part being supported by the engine base, so that the shaft lies in it, and the other part covers the shaft at the same point, being held by CAP bolted to the engine base.

There are Plates of Brass Between the Edges of the Bearings, called LINERS.

When a Bearing Wears and the shaft becomes loose in it, the liners are taken out and filed thinner, so that when they are replaced they permit the two halves of the bearing to be drawn closer together, taking up the wear.

The Bearings must fit the shaft exactly, and must not be so tight that they bind, or prevent easy motion.

The Bearings Must Fit the Shaft Exactly, and to insure this they are SCRAPED.

If a Set of Bearings is to be Scraped, the crank shaft is disconnected, and the surface that rest in the bearings given a very thin coating of Prussian blue.

The Shaft is Then Replaced in the Bearings, and revolved a few times by hand.

If the Bearings Fit, all of the Prussian blue will be evenly removed.

If They Do Not Fit in some places the Prussian blue will be removed, and in others it will not be touched.

Where the Prussian Blue is Wiped Off the crank shaft indicates a "high spot" in the bearing, which must be scraped down.

The Tool Used is a Curved Scraper, slightly spoon shaped, with a long handle, so that it may be guided by one hand and turned with the other.

After Every Scraping, the shaft is again colored, and revolved in the bearing.

As the High Spots are Removed by the Scraping, the bearing will come to a better fit, and the process should be continued until the fit is perfect.

A Triangular File, ground down until the edges are sharp, makes a good scraper.

While the Scraping Requires Experience to Insure a Good Job, it is Not Difficult, but the novice should be content to scrape slowly. Repairing engines will be treated further on.

CONNECTING ROD AND WRIST PIN.

The Big End of the Connecting Rod is attached to the crank pin, and a bearing of bronze or other metal in the form of a bushing surrounding the crank pin is secured in it. (Chart 36.)

The Bushing is Split Lengthways Into Two Pieces, like the bearing of the crank shaft, one part being set in the connecting rod, and the other being held in place by the CONNECTING ROD CAP.

The Small End of the Connecting Rod contains a solid bushing that forms the wrist pin bearing.

Because of the Small Space in the piston, it is not possible to have this bushing split and held in place by a cap.

The Bushing is Therefore Set in the Connecting Rod, and the wrist pin pushed through it.

The Wear on the Wrist pin Bearing is Slight, and if it should wear loose, a new bushing is driven into the connecting rod.

The Wrist Pin is Passed Through the Piston, and secured so that it cannot move.

Through the Connecting Rod, the piston transmits the pressure of the explosions to the crank shaft, and during the three strokes when the piston is making the compression, exhaust and inlet, the connecting rod transmits to it the movement of the crank shaft and fly wheel.

In Order That It May Withstand the Heavy Shocks of the Explosions the connecting rod must have great strength.

It is Made of Steel or Bronze, with a rib running lengthways on each side, so that it has a cross section like the letter H.

PISTONS AND PISTON RINGS.

The Piston of a Gasoline Engine is Called a Trunk Piston, to distinguish it from the DISC PISTON of a steam engine.

A Trunk Piston is longer than its diameter, and is hollow, with one closed end. (Chart 36.)

The Closed End is Toward the Combustion Space, and it is against the closed end that the force of the explosion acts.

The Wrist Pin Passes Through the Piston, about half-way between the ends.

The Open End of the Piston, permits the connecting rod to swing from side to side.

The Piston Does Not Fit the Cylinder Tightly, for a tight fit would cause friction and wear.

The Pressure From the Explosion is prevented from escaping between the piston and the cylinder wall by PISTON RINGS.

The Piston Rings Fit in the Groove Around the Upper End of the Piston, and there may be from three to five of them. (Chart 36.)

The Rings Fit the Groove Snugly, but are not so tight that they may not move freely.

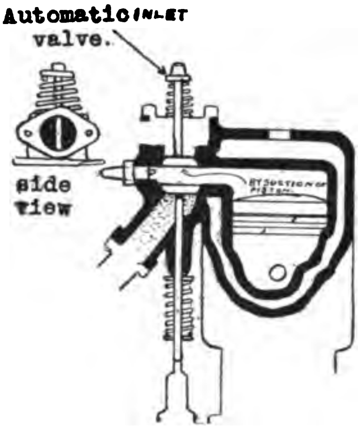


Fig. 1. Showing view of cylinder with an "automatic" inlet valve. Exhaust valve "mechanically" operated.

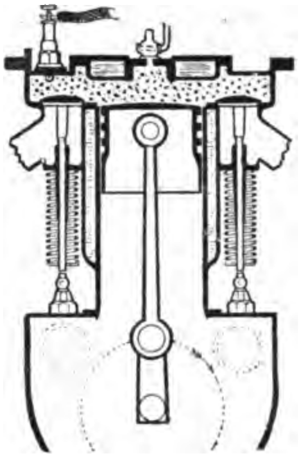


Fig. 2—"T" Head "mechanically" operated inlet and exhaust valve.

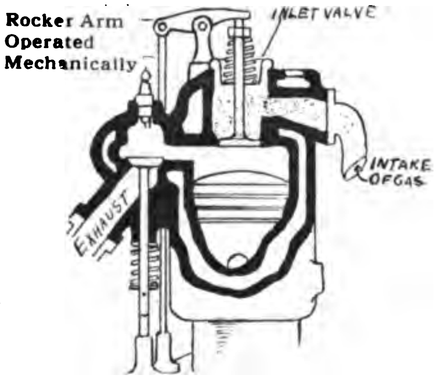


Fig. 3. "Overhead Rocker Arm". Both inlet and exhaust "mechanically" operated.

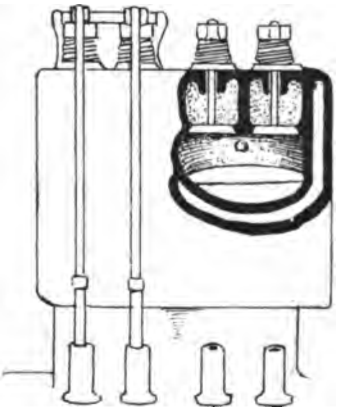


Fig. 4A—Overhead Rocker Arm, "mechanical" inlet and exhaust valve.

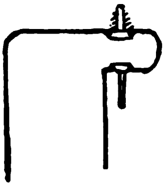


Fig. 1.

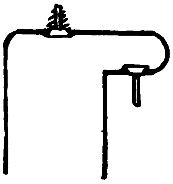


Fig. 3.

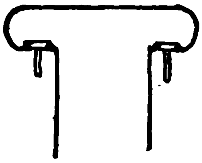


Fig. 2.

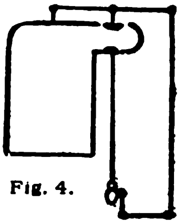


Fig. 4.

Fig. 1-3-4 are types of cylinders with all the valves on one side of the cylinder. Called the "L Head" type of cylinder.

Fig. 2.—The exhaust valves are on one side and the intake valves on the opposite side. Called the "T-Head" type of cylinder.

Fig. 1-4 have the valves arranged; intake over the exhaust valves.

Fig. 3 has the intake valve in the center of the head of the cylinder, and the exhaust valve on the side.

Fig. 2.—Exhaust on one side and intake on the other side. Two valve chambers.

Fig. 4.—Illustrates an "overhead operated" valve arrangement. Instead of the plunger pushing the valve up direct as shown in **Fig. 2**, the plunger pushes a rod which operates a rocker arm (see fig. 3). The valves are of course "mechanically operated." Sometimes the intake valve is arranged with an overhead rocker arm with the exhaust operated as usual. (**Fig. 3**).

Again, some manufacturers operate both intake and exhaust with overhead rocker arm arrangement, (**Fig. 4A**).

The construction varies, but the principle and purpose is to open the intake valve at the right time to take in a charge of gas and open the exhaust valve at the right time to discharge the burnt gas.

Various and Standard Types of Valve Arrangements.

CHART No. 38.

They are Cut CrossWays, so that they may be sprung open.

When Closed, so that the ends touch, the rings are a trifle smaller than the diameter of the cylinder.

When Sprung Open, they are larger than the diameter, or BORE, of the cylinder.

They are So Made that they always stand a little open.

The Rings are Slipped Into the Grooves by springing them open, and sliding them over the piston.

When a Piston is to be Placed in a Cylinder, the rings are closed, so that they will slide in.

The Piston With Its Rings Fits the Cylinder Snugly, and the elasticity of the rings keeps them pressed against the cylinder wall, making a fit that keeps the pressure from escaping.

None of the Pressure of the Explosion Being Able to Escape, it is all exerted against the closed end of the piston, or PISTON HEAD

The Rings Must be Placed on the Piston so that the ends are not one over the other, for if they were in line the pressure might escape through them.

The Rings are Prevented From Moving Around the Piston by Pins placed between the ends.

The Only Motion They Have is the spring in and out.

The Ends of the Rings are Beveled, or made with a joint that is shaped so that it is tight whether the rings are closed, or open to the size of the cylinder.

Two Methods of Making the Joint are shown on Chart 36.

Pistons and Piston Rings are made of CAST IRON.

VALVES.

The Valves May be Placed in the Cylinder in Various Ways, as shown in Chart 38.

Both may be in the cylinder head as shown in Chart 38, Fig. 4A.

One May Be in the Head, and the other in a projection on one side of the combustion chamber, called a VALVE CHAMBER. (Fig. 3)

Both may be in one valve chamber. (Fig. 4.)

There May Be Two Valve Chambers, with one valve in each. (Fig. 2.)

A Valve Has Two Parts: a valve DISC with a STEM, which forms the moving part, and a VALVE SEAT ,on which the valve fits.

When Closed, the Valve Disc Must Fit the Seat so that it is absolutely tight.

When Open, there must be sufficient space to let the gas pass freely.

Valves for Gasoline Engines are of Two Kinds, FLAT SEAT and CONICAL SEAT. (See Chart 36.)

In a Flat Seat Valve, the valve disc and seat are flat and true to each other, the disc closing the seat as a half-dollar closes the end of a gasoline pipe when held against its end.

The Seat of a Conical Valve is Funnel Shaped, and the valve disc is cone shaped to fit it.

In Gasoline Engines the Valves Open Inward, so that the pressure during the compression and power strokes holds them tightly on their seats.

Valve Discs and Stems are made in one piece, for strength.

Coil Springs Around the Stems draw the discs to their seats, so that to open the valve the spring must be compressed.

It is Better to Have a Large Valve that moves only a short distance when opening, than a small valve moving a longer distance.

MECHANICALLY OPERATED VALVES.

The Stem of a Mechanically Operated Valve usually extends about half way to the cam shaft, a VALVE LIFTER ROD, or PUSH ROD, being placed below the valve stem, so that the cam operates it. (See Chart 29.)

When the Cam Turns, it lifts the valve lifter rod, which in turn lifts the valve stem. (See Chart 35.)

There is a Space of About 1-32 of an Inch between the valve lifter rod and the valve stem, which permits the spring on the valve stem to always bring the disc firmly to its seat.

If No Space Was Left Somewhere Between the Valve Disc and the cam, even very slight wear of the disc and seat would prevent the valve from closing properly.

In the Winton engine and some others, the valve stem extends to within a very small distance of the cam, and there is no valve lifter rod.

The Spring of a Mechanically Operated Valve does not need adjusting, so long as it is strong enough to bring the disc quickly to its seat as soon as the cam has passed from under.

AUTOMATIC VALVES.

The Correct Adjustment of the spring of an automatic valve is important in the action of the valve. (See Chart 34 "F.")

It Should be Weak Enough to Open Quickly at the beginning of the suction stroke, and strong enough to pull the disc quickly to its seat as soon as the suction ceases.

If It is Too Strong, it will take more suction to overcome it ,which may make the valve open too late, and if it is too weak it will not close soon enough, so that part of the fresh charge will be pushed back to the inlet pipe on the compression stroke.

There is often an Adjusting Screw or nut by which the spring may be strengthened or weakened.

If There is no Adjusting Screw, the spring may be strengthened by taking it off the stem, and stretching it slightly.

To Weaken It, cut off a half-turn or more.

An Automatic Valve; the seat, valve disc and stem, and spring, are contained in the INLET VALVE CAGE. (Chart No. 36.)

The Cage May Be Easily Removed from the engine, as it is either screwed in or bolted on.

In Engines of More Than One Cylinder, the springs of automatic inlet valves should have the same strength, or TENSION.

This is Determined by Removing the Cages from the Engine, and holding one in each hand, the ends of the valve stems are pressed together, so that the discs leave their seats.

If the Springs are of Equal Tension, the valves will open equally, but if not of the same tension, the weaker spring will allow a greater opening of its valve.

If the Valves Do Not Open Equally, the adjustment must be made for unequal opening of the valves will result in the cylinders sucking in unequal amounts of gas, which will make the engine run unsteadily.

As the Springs are Constantly in Motion, especially when the engine is running fast, they are liable to break ,and extra ones should always be çarried.

It is Not Difficult to Replace Them, and having spare springs will often prevent being held up on the road on this account.

VALVE GRINDING.

The Valves are Exposed to the Force and Heat of the Explosion, which in the course of time will effect them so that they will Not Seat **Tightly.**

This Will Give Weak Compression, and loss of power on the power stroke.

The Exhaust Valve, especially, is surrounded by flame when open, and will become pitted.

In a Perfect Fitting Valve, the disc and seat are smooth, flat and even, with dull gray surface.

A Pitted Valve is Rough, uneven, and full of tiny holes, and cannot come to a tight seat. The valve must then be ground.

To Release and Remove a Valve, the spring must be taken off, and as it is usually held by a washer and split pin, it is only necessary to remove the pin.

The Process of Grinding a Valve is the placing of a grinding paste between the disc and the seat, and the revolving of the disc until the roughness is worn down.

A Good Grinding Paste May be Made of Flour of Emery and machine oil, the two being mixed so that the paste is stiff.

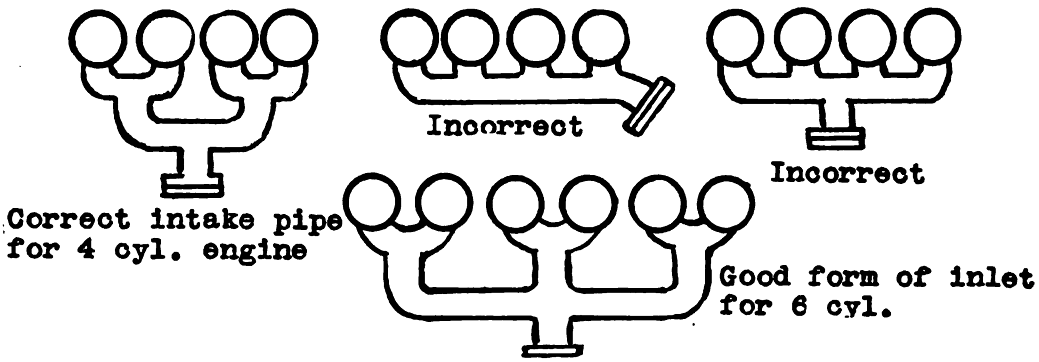
The Upper Side of the Valve of the Disc has a slot to receive the blade of a screw driver.

Spread a Small Quantity of Paste on the Seat, and inserting the blade of a screw driver in the slot, rotate the disc back and forth holding it firmly against the seat.

Lift the Disc Every Little While, and give it a new position on the seat, to distribute the wear evenly.

A Bit-Brace, or Automatic Double Acting Screw Driver, are of assistance in grinding, as they are not so tiring to operate as a screw driver.

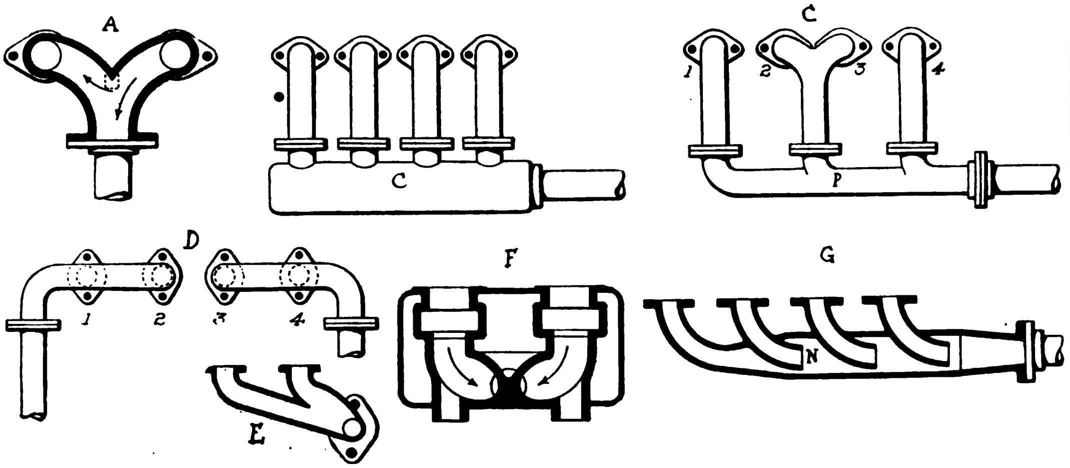
In Grinding a Mechanically Operated Valve, care should be taken that none of the paste falls into the cylinder, as it would cut the walls and piston rings.


Correct intake pipe for 4 cyl. engine
Incorrect
Incorrect
Good form of inlet for 6 cyl.

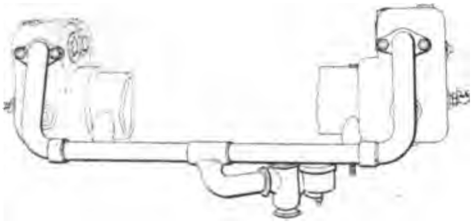
Inlet piping for 4 & 6 cylinder engines.

Intake Manifolds.

The Distribution of Gas to a Multiple of Cylinders is a Problem. The Carburetor should be placed as near equal distance to each cylinder as possible. The distance from Carburetor to Intake Valve must be as short as possible otherwise the gas will condense before it reaches the Valve Port and starting will be difficult. The pipes should be of ample size and free from sharp bends and projections.



Illustrating Various Methods of Placing Exhaust Manifolds on Motors.



Good practice in manifolds for double opposed motors, showing connections on one side of motor for both cylinders.

Exhaust Manifolds.

"A" Shows a good method of Exhaust Outlet for a 2-cylinder Vertical Engine.

"B" Shows a simple manifold in which an individual pipe from each cylinder injects directly into the large collector chamber C. In this manfold the collector tube is made sufficiently large so that when the exhaust valve closes, the pressure in it is less than that in the cylinder at the valve so that there is no danger of back pressure.

"C" Shows an arrangement in which the pipes 2 and 3 for the middle chambers are formed in one, whereas they are separate for cylinders 1 and 4. This works satisfactorily in that cylinders 2 and 3 never explode consecutively, and the one pipe is capable of taking care of the exhaust of the two.

The exhaust manifold illustrated in D is quite similar to that in Fig C excepting in that there are individual pipes for cylinders 1 and 2, and 3 and 4. This is bad construction in that 4 explodes immediately after 3, and 1 immediately after 2, and we find exhaust gases from 4 will enter 3 and exhaust of 2 will enter 1.

As the direction of exhaust leaving the cylinders is the same it is very easy to make a manifold in which the exhaust pipe, instead of having a tendency to obstruct one another assists the other cylinders to exhaust. **In motors which have their intake and exhaust valves opposite,** frequently all four of the exhaust valves are connected through one manifold with a single orifice **Fig. F is one example of an arrangement where it is possible to make the two passages unite.** This is suitable for motors with cylinders cast in pairs. **The defects of A and D** can readily occur in this one if makers were considering loss of power they would not use this one, but they only want to save space. **For the best design,** illustration G offers a reasonable solution. **In this illustration there is an individual pipe** from each cylinder to the large collection. **At the end each individual pipe** projects into the collector tube and curves in the direction of the exit for this collector tube.

CHART No. 39.

A Plug of Cotton Waste on the valve opening will prevent it.

To Test the Grinding, clean off the paste, replace the spring, moisten the edges of the valve with soapy water, and crank the engine, being sure that the other openings into the cylinder are tight.

If the Fit Is Not Perfect, bubbles will appear around the valve during the compression stroke, and grinding must be continued until the fit is perfect.

To Grind an Automatic Inlet Valve, the cage should be removed from the cylinder, and the valve stem spring released.

The Cage Should Be Held in a Vise, so that the valve disc may be ground against its seat.

The Grinding is the same as described for a mechanically operated valve.

To Test, replace the spring, and holding the cage upright, pour a small quantity of gasoline into the hollow side.

If the Gasoline Leaks through, the fit is not perfect.

A Leaky Valve means loss of power, or failure of the engine.

The Valves should be examined regularly, and the fit kept as perfect as possible.

After Grinding, all traces of the paste should be removed from the disc and seat, as otherwise the parts will wear rapidly.

Further explanation on grinding valves under "Repairing."

INLET PIPE.

Because the Mixture of Gasoline Vapor and Air Corrodes Iron and Steel, the INLET PIPE from the carburetor to the inlet valve chamber is made of copper or brass.

In Order That There May Be as Little Resistance as possible to the flow of the mixture, this pipe should be as straight as the position of the carburetor will permit.

There Shoud Be No Sharp Angle Bends, the bends being as flat and easy as possible.

When More Than One Cylinder is Supplied From One Carburetor, the distance from the carburetor to each inlet valve should be the same.

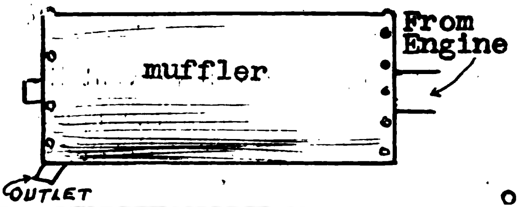
Chart 39 Shows diagrams of inlet pipes from a carburetor to the four inlet valves of a four cylinder engine.

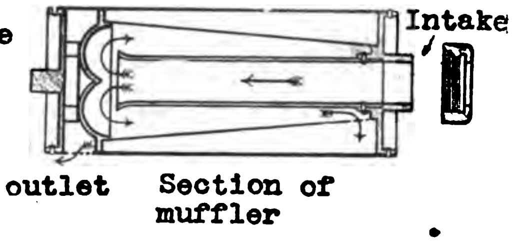
In Those Marked "Incorrect" the distances form the carburetor to the inlet valves are not equal, and consequently the valves nearest the carburetor will get more of the mixture than those farther away.

In the Arrangement Marked "Correct" the Distances are Equal and consequently the valves get equal quantities of mixture, and the engine will run more evenly than if the cylinders received different amounts.

EXHAUST PIPE.

In Order That the Exhaust Pipe May Be Cooled as Rapidly as Possible, the EXHAUST PIPE, connecting the exhaust valve chamber to the muffler, is exposed to the air. (See Chart 39.)





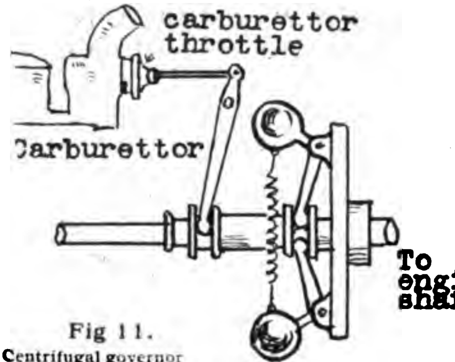


Fig 11.
Centrifugal governor acting on throttle controlling speed witnin a certain fixed range.

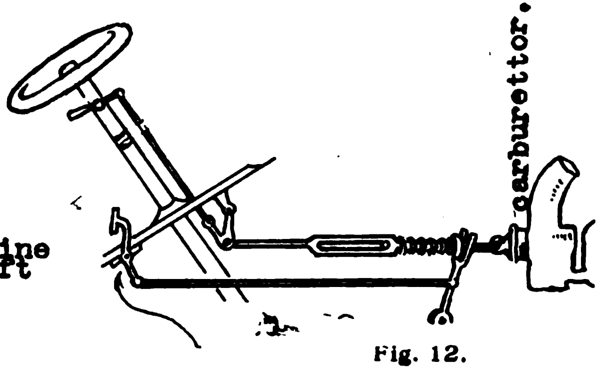


Fig. 12.
Pedal accelerator acting direct on throttle, with hand lever throttle combined.

The Muffler is placed on the end of the exhaust pipe in order to silence the noise of the exhaust. It is usually made of sheet iron and piping as shown in section. Sometimes the mufflers are not sufficiently large enough to expel the burnt gas as rapidly as it should be and heating is the result. Sometimes the mufflers clog up with soot and cause heating.

Governor. Fig. 11. As the Engine speeds up the balls fly outward and the sleeve is moved forward and thereby opens throttle of carburetor. (The governor is now seldom used).

The Accelerator is merely a foot lever for controlling the throttle independent of the governor.

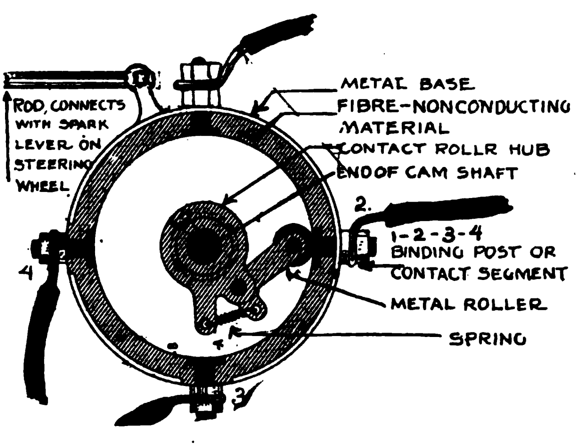

ROD, CONNECTS WITH SPARK LEVER ON STEERING WHEEL
METAL BASE
FIBRE-NONCONDUCTING MATERIAL
CONTACT ROLLR HUB
END OF CAM SHAFT
2.
1-2-3-4 BINDING POST OR CONTACT SEGMENT
METAL ROLLER
SPRING
4
3

Fig. 14.—Timing Device.

The Timing Device is so named because it "times" the spark at the right time. In other words the roller makes contact with one of the segments (1-2-3 or 4). Each segment controls one of the spark plugs (through a coil) in one of the four cylinders. When the right cylinder is ready to fire the timer makes contact and starts the coil which sparks the plug.

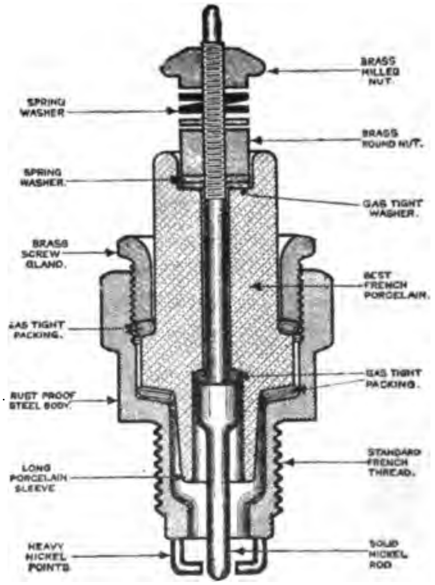


Fig. 15.—Spark Plug Construction.

The Spark Plug is placed on the head of the cylinder. A wire is connected from this plug to a spark coil. The spark coil is set to work at the right time by a timer. When the coil is operating an electric spark occurs at point of the plug, inside the cylinder, and ignites the compressed gas.

CHART No. 40.

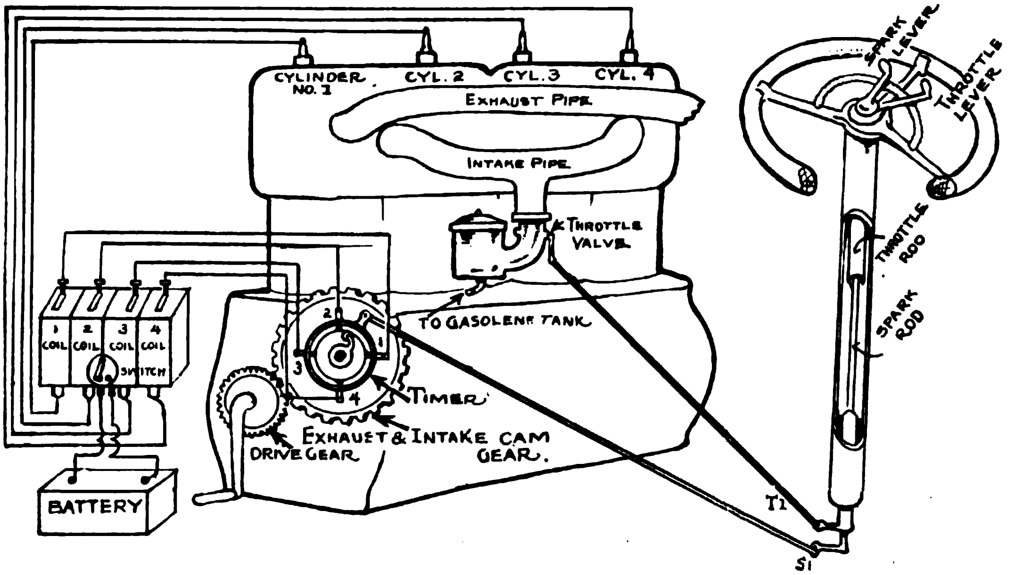


Figure Illustrating the Speed Control Levers and How They are Connected.

Illustration explaining how the timer is connected to the cam shaft, and how it is shifted—"advanced" or "retarded" with "spark lever" on the steering wheel.

The illustration also explains how the "throttle" on the Carburetor is opened and closed by the "throttle lever" on the steering wheel.

The Speed of an Engine is Increased by "opening the throttle" of the carburetor and permitting gas to be sucked into the cylinder.

The Speed is Decreased by "shutting off" this admission of gas into the cylinder.

The spark or timer contact must be "advanced" so that the ignition will occur earlier when the engine is speeded up.

The spark or timer contact must be "retarded" (shifted back) when Engine speed is reduced.

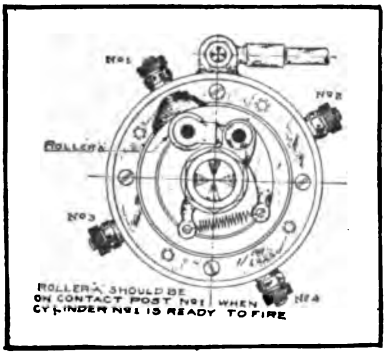

No 1
No 2
No 3
No 4
ROLLER A
ROLLER "A" SHOULD BE ON CONTACT POST No 1 WHEN CYLINDER No 1 IS READY TO FIRE

Fig. 2.—The Timer or Timing Device. Also sometimes called a "commutator"; also "igniter box." "Timer" is correct. Similar to Timer in Chart No. 40.

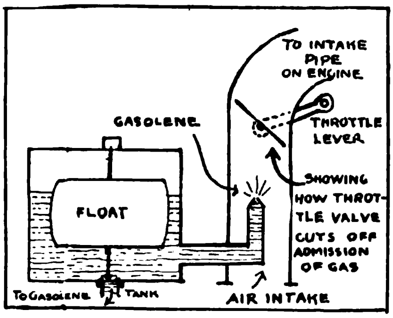


Fig. 3.—Section View of the carburetor showing how the throttle valve cuts off the gas supply to Engine when closed, or when open admits gas to Engine.

The Muffler and Exhaust Pipe should be made so that there is as little BACK PRESSURE as possible.

Back Pressure, caused by anything that prevents the free escape of the gas, does not permit the burned gas to pass out of the exhaust valve readily, and more of it remains in the cylinder.

The Incoming Fresh Mixture becomes mixed with that part of the burned gas left from the previous charge, and the power of the engine is cut down accordingly.

Sharp Bends in the Exhaust Pipe Cause Bad Back Pressure, and should be avoided.

Dirt in the Pipe or the Muffler Has the Same Effect, and this should be guarded against.

SPARK PLUGS

The Device Connected in the IGNITION CIRCUIT at which the spark is produced is called the SPARK PLUG, and it is located in the upper part of the combustion space. (See Chart 29 and30-31 also illustration of plug, Fig. 15, Chart 40.)

COMMUTATOR OR TIMING DEVICE.

This device is usually placed on the end of the cam shaft, (See Chart 40A) the purpose being to make electrical contact at the proper time to ignite the gas through the spark plug when the gas is under compression in the cylinder.

One part of the timer is stationary and the other revolves, being attached to the half time shaft. (See Fig. 14, Chart 40.) This device and other parts of the ignition subject will be explained further on.

SPEED CONTROL OF AN ENGINE.

Is controlled by opening the THROTTLE VALVE on the Carburetor. (See Chart 40A which gives a full explanation)

GOVERNOR.

The Engine is Often Prevented Fron Running Beyond a Fixed Speed by the GOVERNOR, except at the will of the driver.

Its Principle is the Same as That of the Governor of a steam engine.

A Wheel on a Shaft is Arranged With Two Weights on opposite sides of the shaft, so that they may move toward the shaft or away from it.

When the Shaft Revolves, CENTRIFUGAL FORCE throws the weights outward.

The Weights of a Governor are Drawn Toward the Shaft by Springs, Chart No. 40, Fig. 1.

When the Governor revolves, the weights move outward against the springs, being brought to the shaft again when the revolution ceases.

The Faster It Turns, the farther out the weights are moved.

This Opens and Closes the Throttle of the carburetor and thereby governs the speed.

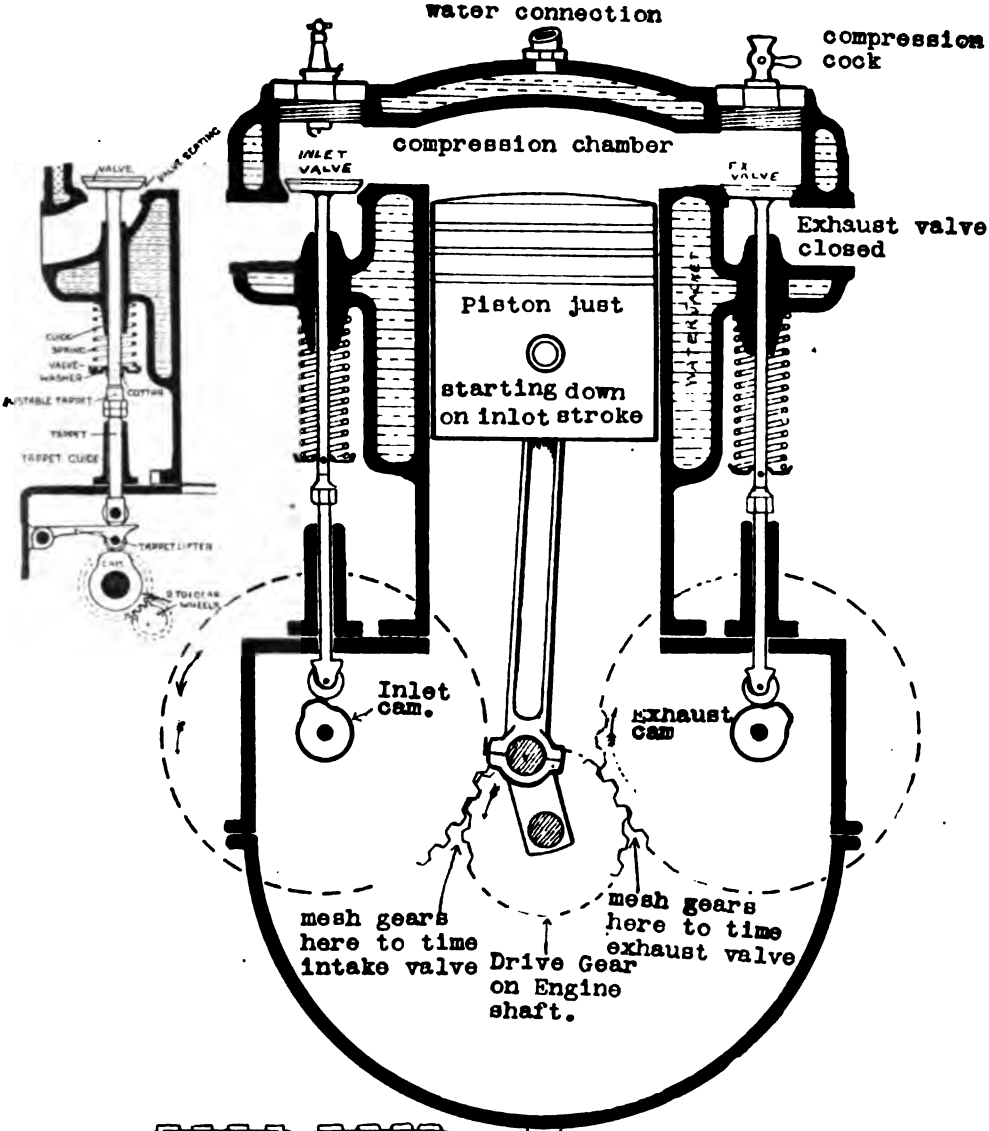


Fig. 2.

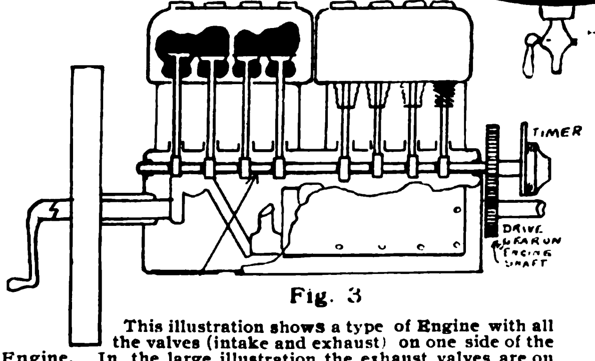
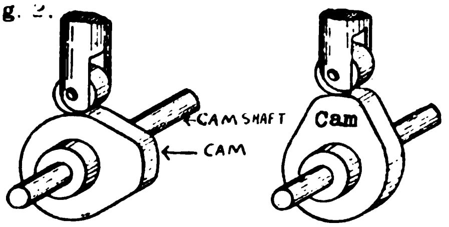


Fig. 3

This illustration shows a type of Engine with all the valves (intake and exhaust) on one side of the Engine. In the large illustration the exhaust valves are on one side and and the intake valves on the other.



Note the nose on the cam.

This illustration explains the arrangement of valves on the "T" head type of Engine. If the reader will refer to Master Chart 29 and the Engine Working Model the explanation will be clear. The Engine may be a 1, 4 or 6 cylinder Engine and the view above shows the end cylinder cut in half. The small view of Engine at lower left shows an Engine with all the valves on one side and operated by one cam shaft.

CHART No. 41.

INSTRUCTION No. 9.

VALVE TIMING.—Timing with the Exhaust. Finding the Position of the Piston. Plan of Procedure. Hints on Valve Timing.

VALVE TIMING.

The Setting of the Mechanically Operated Valves, so that they open and close at the proper time, is called VALVE TIMING, or VALVE SETTING.

Because the Cam Shafts are Driven by Gears, they do not open and close the valves incorrectly unless the gears are taken out of mesh, which may be done for cleaning, or accidentally.

The Action of the Valves Depends on the Position of the Cams on the cam shaft, and their position is according to the position of the gears.

The Gears are Usually Covered by a casing bolted to the crank case.

Pulling the Gears Out of Mesh makes it possible to turn the cam shaft independently of the crank shaft. (See Chart 35.)

The First Step in the Timing of a Mechanically Operated Valve is to make sure of the position of the piston in the cylinder.

TIME WITH THE EXHAUST.

This is Necessary because the exhaust valve must be so timed that it CLOSES WHEN THE PISTON HAS MOVED ABOUT ONE EIGHTH OF AN INCH DOWN ON THE SUCTION STROKE. (Chart 41.)

The Exact Point for Closing can only be determined by experiment.

FINDING THE POSITION OF THE PISTON

If There is a Hand Hole in the Crank Case, the position of the crank can be seen, which of course indicates the position of the piston.

The Most Accurate Method is to Stick a Stiff Piece of Wire, like a bicycle spoke, into the opening in the cylinder head directly over the piston such as the spark plug opening, or the relief cock.

The Lower End of This Wire Rests on the Piston Head, and the other sticks some distance out of the opening.

When the Engine is Turned Over by Using the Starting Crank, the wire moves up and down in following the movement of the piston.

PLAN OF PROCEDURE.

Crank the Engine until it is coming up on the exhaust stroke.

Move It Very Slowly, and when the piston has moved down on the suction stroke about one eighth (⅛) of an inch, stop.

Turn the Exhaust Cam Shaft by Hand until the cam is in such a position that the exhaust valve just closes: then slip the cam shaft gear into mesh with the crank shaft gear. (See position of cams, piston, etc., in Chart 41.)

With the Wire Still Resting on the Piston, turn the engine over until the piston is again coming up on the exhaust stroke, when the motion must be very slow, and the movement of the valve stem, which is in sight, watched closely.

If a Mark is Made on the Wire When the Piston is at Its Highest Point, it will be easier to do an accurate piece of work.

The Valve Should Be Closed by the Time that the wire has moved 1/8 of an inch down.

If the Valve Appears to be Set Correctly, the engine should be started and run.

HINTS ON VALVE TIMING.

Whether or Not the Valve is Set Correctly can be determined by the action of the engine; if it closes too soon or too late the engine will not develop full power.

No Exact Rule Can Be Given for the Setting of This Valve, for it depends on its size, the amount it opens, and the size of the cylinder.

If It Does Not Act Correctly, change the gears so that they are shifted one tooth, first one way then the other, and leave them in the position that gives the best results in the running of the engine.

The Cams for the Inlet and Exhaust Valves are Sometimes on One Shaft, (per Fig. 3, Chart 41) so that setting one valve correctly sets all the valves.

If the Mechanically Operated Inlet Valves are Controlled by a Separate Cam Shaft, (Fig. 2 Chart 41) they should be set so that the inlet valve opens just as the exhaust valve is closed.

In Low Speed Engines, such as are used for stationary power plants, the exhaust valve closes at top dead center, but on high speed automobile engines the valves set as described will be correct.

Cam Shafts are Driven by a Gear on the Crank Shaft That Meshes Directly With the Gear on the Cam Shaft, in which case the shafts revolve in opposite directions, or sometimes there is an idle gear between the two, in which case the shafts revolve in the same direction.

THE TIMER.

It is Also Necessary to Set the Ignition Timer, so that the spark is passed at the right instant.

The Timer (Fig. 1, Chart 40A) is Usually Attached to the Cam Shaft by a Key and Key-Way, or by a clamp.

If Held by a Key, it will fit on the shaft only in the correct position, but if clamped, it must be adjusted.

Remove One of the Spark Plugs, connect it, and lay it in the engine as if for testing.

Place the Lever on the Steering Column in the Retarded Position, and crank the engine slowly until the piston is at the top of the compression stroke.

The Timer Should Then Be Clamped in Position so that contact is just beginning to be made.

STARTING THE ENGINE.

In Starting the Engine with the starting crank, the spark lever (See Chart 40A) must be retarded so that combustion occurs when the piston has begun to move outward on the power stroke.

Advance the Spark by Moving the Lever, and it should pass considerably before the compression stroke is completed.

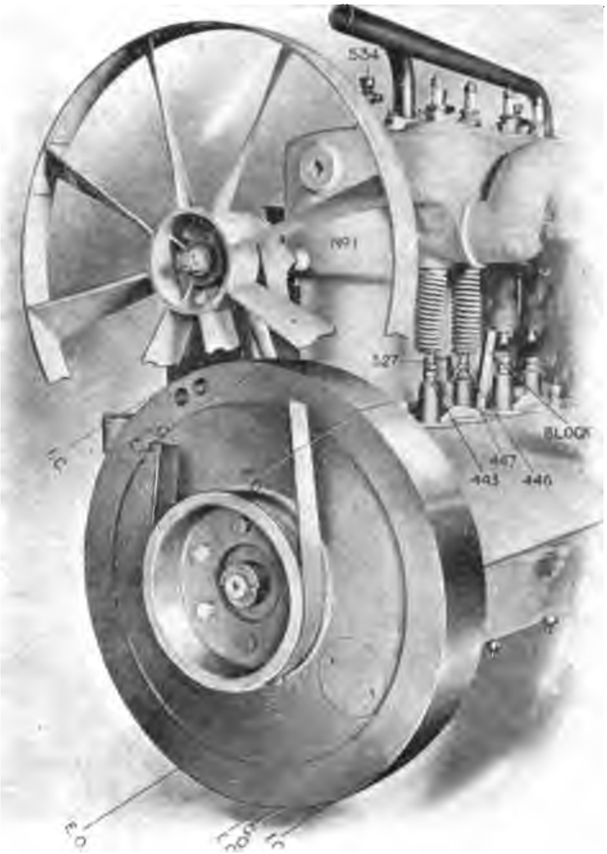
When Taking an Engine to Pieces, and it is necessary to remove the valve timing gears, make marks on two teeth that touch when the gears are correctly meshed, using a center punch of cold chisel.

This Will Be a Guide in Replacing the Gears, for they may be replaced on the shaft so that the marks come together, and retiming will not be necessary.

In Many Cases This is Done by the Manufacturers, and such marks should always be carefully observed.

How to Time the Exhaust and Intake Valves of an Engine.

(Stevens Duryea Model as an Example.)



The inspection or adjustment can be very easily accomplished by opening pet cocks No. 534 and rotating fly wheel by hand (in direction motor runs). If timing gears are replaced, it will be necessary to retime the valves as the gears are not marked until after the motor is timed at the factory

Timing the Exhaust Valve.

Begin with No. 1 cylinder. turn fly wheel until exhaust valve lifter No. 443 comes in contact with valve stem No. 527. The mark on highest point in travel of fly wheel should read E. O.—(exhaust valve opens). If mark has passed or has not reached highest point, bring mark to proper position and adjust the tappet stud until it just makes contact with valve stem No. 527. Then lock with lock nut, then turn motor 4½ inches more than ½ revolution of fly wheel until mark "C"—(center) I. O. (inlet opens) and E. C. (exhaust valve closes) are at the highest point in travel of fly wheel. Valve lifter No. 443 should just be free from exhaust valve stem No. 527.

Timing the Intake Valve.

Intake Valve—Leave fly wheel in same position and examine valve lifter of intake valve of same cylinder. Lifter should just be in contact with intake valve stem, then turn fly wheel 4½ inches more than ½ revolution of fly wheel which will bring I. C.—(inlet closes) to the highest point. Valve lifter should then be just free from inlet valve stem.

Cylinders Nos. 2, 3 and 4 are timed in exactly the same manner as No. 1 Simply turn fly wheel until exhaust valve starts to open (of the cylinder you are inspecting), then proceed as with No. 1 cylinder. The valves of No. 2 cylinder are blocked up. This is to show what is to be done to the valves if cam shafts are to be removed. The blocking of the valve relieves the strain on cam shaft and it will be found much easier to block them up than to move the entire line of tappets.

CHART No. 42.

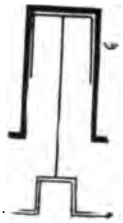


Fig. 1.

One Cylinder Engine with crank shaft set at **360 degrees.**

Crank shafts on one-cylinder Engines are counter-balanced with weights on the side of the crank shaft.

Firing Order of a 1-cylinder Engine.

1 Power Stroke every Two Revolutions.

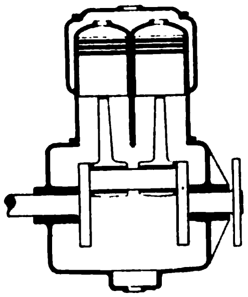


Fig. 2.

Two-Cylinder Vertical Engine.
Crank shaft set **360 degrees.**
Counter balanced crank.
Firing order.

Power Stroke Every Revolution.

CYLINDER NO.	1
1ST REVOLUTION	S
	C
2ND REVOLUTION	P
	E

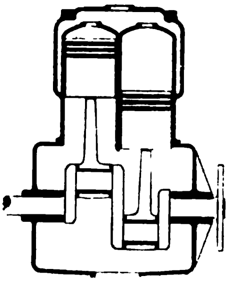


Fig. 3.

Two-Cylinder Vertical Engine.
Crank shaft **180 degrees.**
Both power strokes during one revolution.

Two Different Orders of Firing Shown Below.

CYLINDER NO	1	2
1ST REVOLUTION	P	C
	E	P
2ND REVOLUTION	S	E
	C	S

OR

CYLINDER NO.	1	2
1ST REVOLUTION	P	E
	E	S
2ND REVOLUTION	S	C
	C	P

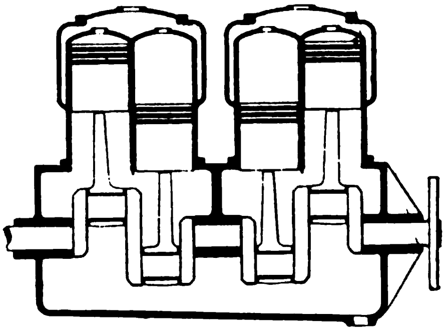


Fig 5.

Four Cylinder Engine. Crank shaft set **180 degrees.**

Power stroke every half revolution.

Two Different Orders of Firing Below.

CYLINDER NO	1	2	3	4
1ST REVOLUTION	P	E	C	S
	E	S	P	C
2ND REVOLUTION	S	C	E	P
	C	P	S	E

FIRES 1-3-4-2

OR

CYLINDER NO	1	2	3	4
1ST REVOLUTION	P	C	E	S
	E	P	S	C
2ND REVOLUTION	S	E	C	P
	C	S	P	E

FIRES 1-2-4-3

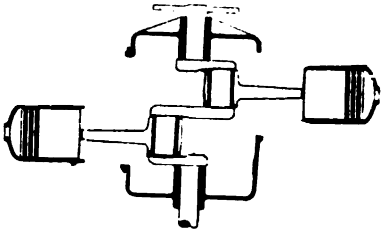


Fig. 4.

Two Cylinder opposed type of Engine.
Crank shaft set **180 degrees.**
Mechanically balanced shaft. Order of firing.

1 Power Stroke Evrey Revolution.

1	2	CYLINDER NO
P	S	1ST REVOLUTION
E	C	
S	P	2ND REVOLUTION
C	E	

A degree is explained by a complete ° circle which is **360 degrees**—if this circle is divided in half as shown in Fig. 3, 4 or 5 then the crank is **180°**, or if as shown in Fig. 7, **120 degrees** or ⅓ of the **360 degrees** of a circle. Fig. 1 and 3 would make a circle or full degree, then they are called a **360 degree** crank.

A small round figure ° shown at the side of a figure means degree.

Explanation of meaning of the letters above are given in illustration Fig. 10.

Power Stroke	P
Exhaust	E
Suction	S
Compression	C

CHART No. 43.

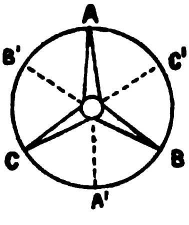


Fig. 6

Explanation of 3 and 6 Cylinder.

The 3 Cylinder Engine fires 1-3-2—In the 3 cylinder Engine the explosion stroke in one cylinder is contemporaneous with two-thirds of an exhaust stroke in another cylinder, with two-thirds of a compression stroke in the third cylinder, and with ⅓ of a suction stroke in both, an interval of ⅓ stroke intervening between the power strokes.

The action of a three-cylinder is understood least of all, as it is not readily followed how the four "cycles" can be completed by three engines equally within the two revolutions of the crank. **The action is this:** Taking three points of the circle A at the top, B and C on each side below, the piston of No. 1 Engine is connected with a crank at A, to No. 2 Engine at B and to No. 3 Engine at C.

No. 1 Engine will be at full compression, No. 2 Engine at ⅔ inspiration, and No. 3 Engine ⅓ exhaust.

No. 1. Engine: The crank of this performs its half revolution, bringing it to position A, midway to points B and C.

Whilst it is doing this, No. 2 Engine is completing its inspiration stroke, and ⅔ of its compression stroke, and the crank is passed on to position B, leaving only one-third of a stroke to complete the compression, and bring the crank to A, when the firing of B commences.

Meanwhile C is completing its exhaust and inspiration strokes, and has passed through three parts of its compression stroke, so that when No. 2 Engine has completed its impulse, No. 3 has but to pass over the small gap and it is that the work of one overlaps that of the other.

This to a very large extent, not only eliminates the absolute pause which exists with the four-cylinder Engine, but also gives an overlapping action which, to a great extent, neutralizes the semi-ineffectiveness of the last part of the firing stroke and so secures an evenness of torque which, although not absolutely even, is far more so than four cylinders.

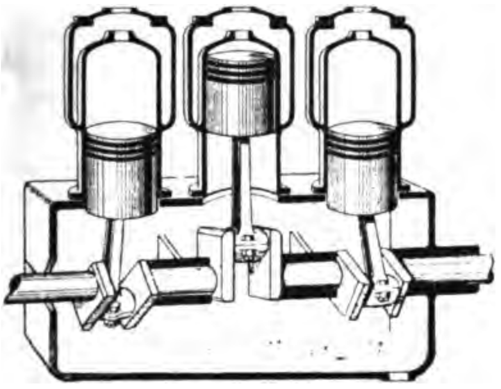


Fig. 7. A three-cylinder Engine.
Crank set **120 degrees.**

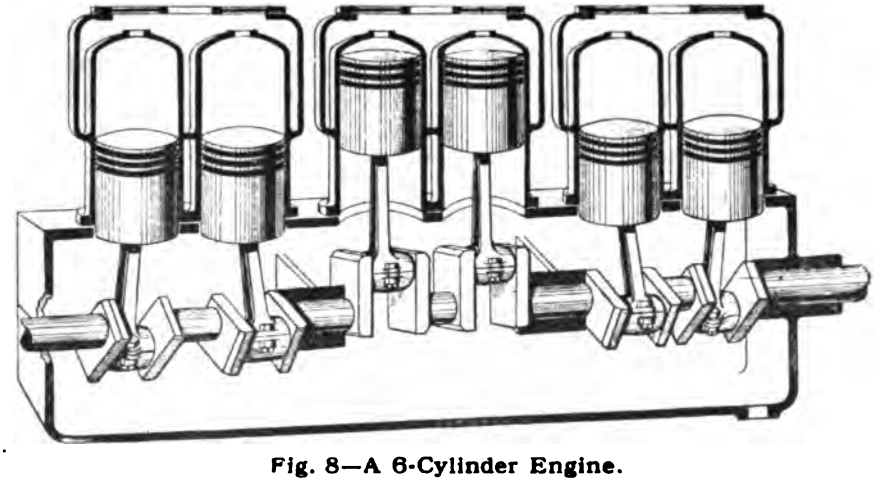


Fig. 8—A 6-Cylinder Engine.

Diagrams explaining how the cranks are arranged on a six cylinder Engine. It consists practically of two Engines, each of three cylinders, coupled together, the centre cranks and each consecutive pair being in the same plane. The cranks (viewed from each end) are set at **120 degrees** relative to each other, except the third and fourth.

The usual firing order of a 6-cylinder Engine is 1-5-3-6-2-4—and 1-4-2-6-3-5.

In the 6-cylinder Engine an explosion stroke in one cylinder is contemporaneous with one-third of an explosion stroke in two other cylinders.

CHART No. 44.

INSTRUCTION No. 10.

ENGINE BALANCE.—Crank Shafts. Degree of Crank Shafts. Order in which Multiple Cylinder Engines fire and why. Usual Engine Troubles. Pre-Ignition. Stationary and Marine Gasoline Engines.

ENGINE BALANCE.

In an Engine With One Cylinder, there is an explosion once during every two revolutions, or in other words, there is one stroke of the piston when power is being developed, and three when there is no power, the piston then being moved by the revolution of the fly wheel.

As the Piston Must Be Carried through the three dead strokes, it is necessary to use a heavy fly wheel, so that when it is started it will continue to revolve for a sufficient time to move the piston until the next power stroke.

There is Vibration from a one cylinder engine on this account, for the weight of the piston sliding first one way and then the other has nothing to balance it.

It Can Be Balanced to some extent by attaching a weight to the crank shaft opposite to the crank pin, in the same manner that the wheels of a locomotive are balanced, but even so there is vibration.

If an Engine is Made With Two Cylinders, one piston can be arranged to slide inward as the other slides outward, so that one balances the other. (Per Fig. 4, Chart 43.)

If the Cylinders are Built Standing side by side, it is called a TWO CYLINDER VERTICAL ENGINE.

If the Two Cylinder Vertical Engine is made with a 180 degree crank shaft (that is, with the cranks projecting from opposite sides of the crank shaft) one piston will be moving up as the other piston moves down, which will give good balance. (See Chart 43, Fig. 3.)

The Defect in an Engine of This Type, however, is that the explosions occur in both cylinders during one revolution, there being no explosion in the revolution that follows.

A Two Cylinder Vertical Engine in which the explosions occur in alternate revolutions would require a 360 degree crank shaft: (that is, both cranks projecting from the same side of the shaft) in which case the two pistons would move up and down together, giving bad balance and great vibration. (Fig. 2, Chart 42.)

In Explanation of This, the four functions must be remembered. In their order, these are:

INLET STROKE,
COMPRESSION STROKE,
POWER STROKE,
EXHAUST STROKE.

The Piston Moves INWARD on the compression and exhaust strokes, and OUTWARD on the suction and power strokes.

If Piston No. 1 of a two cylinder vertical engine with 180 degree crank shaft is moving outward on the power stroke, piston No. 2 will be moving inward, for with that type of crank shaft the pistons move in opposite directions.

The Inward Stroke of No. 2 may be either exhaust or compression stroke.

If Piston No. 2 is moving upward on the compression stroke, it will make the power stroke as soon as it moves downward, the two power strokes therefore occurring one after the other in two successive strokes, or during one revolution.

If Piston No. 2 is moving upward on the exhaust stroke, the previous stroke will have been the power stroke, so that again the two power strokes come in one revolution.

If the Engine is built with a 360 degree crank shaft, while one piston is moving downward on the power stroke, the other, also moving downward, can be making either the inlet or the power stroke.

If Making the Inlet Stroke, it will be necessary for it to make the compression stroke before it can make the power stroke, and therefore there will be one stroke between the power stroke of piston No. 1 and the power stroke of piston No. 2.

This will Give One Power Stroke to each revolution of the crank shaft, but the weight of both pistons moving up and down together will cause great vibration.

The Choice Between These Two Types of 2 cylinder vertical engines lies between a balanced but unevenly-exploding engine, and one that is not balanced but with evenly occurring explosions.

Either Choice is Unsatisfactory, and engines of these types are therefore not used as much as was formerly the case.

When an Engine is Built With Two Cylinders, it is of the OPPOSED HORIZONTAL TYPE. (Fig. 4, Chart 43.)

In This, the two cylinders lie opposite each other, the crank shaft to which both connecting rods are attached lying between them.

The Crank Shaft is 180 degrees; that is, the cranks project from opposite sides of the shaft.

The Pistons Slide Toward the Crank Shaft and away from it together, but as their movement is in opposite direction, they balance and there is very little vibration.

When They Slide Toward the Crank Shaft, each makes an inward stroke in its cylinder, so that one may be on the power stroke while the other is on the suction.

This Gives a Power Stroke and a dead stroke alternately, or an impulse every revolution.

The Horizontal Double Opposed engine is considered to be the best type of gasoline engine for low power, as it gives steady, even impulses, has very little vibration, and has fewer parts to get out of order than an engine with more cylinders.

The Flywheel of a Two Cylinder Engine need not be as heavy as that of an engine with one cylinder, because it is required to carry the piston through only one dead stroke before another power stroke occurs.

The More Cylinders an Engine has, the more steadily it may run, for the explosions may be arranged to follow one another so closely that there is no moment when one of the pistons is not on the power stroke.

The Large Number of Automobiles Engines have four cylinders, so arranged that there is a power stroke every stroke, or two every revolution, one beginning as the previous one ends

The Crank Shaft of a four cylinder engine is always 180 degrees; that is, two cranks project from one side of the crank shaft, and the other two from the opposite side.

Chart 43, Fig. 5 shows an engine with a 180 degree crank shaft for a four cylinder engine.

The End Cranks Project from One Side, and the inside cranks from the opposite side ,one pair thus being half-revolution from the other, or 180 degrees.

Crank Shafts are made in this way because they are stronger and easier to make than if the first and third cranks project to one side, and the second and fourth to the other.

The Pistons attached to the cranks projecting from the same side of the shaft move upward together, and are balanced by the pistons attached to the other cranks, which are moving downward.

This Construction of the Crank Shaft does not permit the explosions to occur in regular order; that is, cylinder No. 1 firing first, and then No. 2, No, 3, and No. 4 last. (The cylinders are numbered from the front, the first being No. 1, and No. 4 being nearest to the driver.)

Because Pistons 1 and 4 Move Together, in opposite direction to 2 and 3, the order in which the explosions occur must be either 1, 3, 4, 2, or 1, 2, 4, 3.

This Must Be Done in Order to Get an Explosion every stroke, two explosions to the revolution, for the same reason that covers the firing order of two cylinder vertical engines.

The Diagrams in Chart No. 43, show the firing of engines of different types.

Cylinders are Fired in the Proper Order by the setting of the exhaust valves and the timer or commutator.

Engines for Racing Automobiles or motor boats are frequently made with eight cylinders, arranged so that there is an explosion every half stroke, or four to the revolution, which gives constant power, as there are always two pistons moving on the power stroke.

The Most Usual Manner of Making a Crank Shaft for such an engine is to take two four-cylinder crank shafts and place them end to end, so that the cranks of one are a quarter-revolution, or 90 degrees, ahead the cranks of the other.

90 Degree Crank Shafts are sometimes cut from a block of steel, and twisted to bring the cranks in the proper relation, but as twisting is liable to injure the metal, it is not recommended.

The Order of Firing Depends on the ideas of the maker, and may be in any one of various combinations.

When an Engine is Made With Three Cylinders, the cranks project from the shaft one-third of a revolution apart, or 120 degrees. (Fig. 7, Chart 44.)

Such an Engine is Well Balanced, and as the explosions occur three every two revolutions, its running is steady.

The Firing Order is regular, 1, 2, 3.

A Type of Engine that is becoming popular is the six cylinder of which the crank shaft is 120 degrees, the six explosions occurring during two revolutions of the crank shaft. (Fig. 8, Chart 44.)

As There is an Explosion Every One-Third of a Revolution, one occurs before the previous power stroke is complete, so that the power delivered is continuous.

Like the Eight Cylinder Engine, there may be several combinations for the firing order, those most in use being 1-3-5-6-4-2, as does the Pierce-Arrow; others fire 1-5-3-6-4-2, as in the English Napier; the Matheson and the Thomas fire 1-4-2-6-3-5; and the Mitchell 1-5-3-6-2-4.

TAKING DOWN AND ASSEMBLING.

When an Engine is to be Taken Down for repair or examination, disconnect the ignition system, and the gasoline and water connections.

Nuts, Washers and Bolts should be loosely replaced, and small parts marked, that they may not be lost or wrongly replaced.

To Remove the Cylinders of a vertical Engine, if a block and tackle is not available, the easiest method is to bind them with a rope to a stout bar of wood, a man at each end of the bar lifting them from their supports.

A Third Man should support the pistons as the cylinders are drawn away from them.

In Replacing Cylinders, great care should be taken that the piston rings are not damaged.

The Opening Into the Cylinder is frequently made slightly cone shaped, so that as the piston slips in the rings are compressed gradually, but when this is not the case, the rings should be tightly tied with string.

As the Piston Enters, and each ring is inside the walls, the string may be removed.

The Two Men Holding the Bar that supports the cylinders should lower slowly as directed by the man who guides the pistons into place.

In Bolting the Cylinders to the crank case, all nuts should be screwed up gently until they begin to bind.

Run Each One Up a Little, keeping the same strain on all, until all are as tight as they can be drawn.

This Method Should Be Followed for any similar job, like the bolting down of a cylinder head, or other piece that is held by a number of bolts.

If One Bolt is Drawn Up Tightly before the others are set up, the parts are liable to be drawn out of line.

In Many Engines, the cylinder head is separate from the main body of the cylinder, and in that case the point is usually made tight by a gasket.

A Gasket is made of material that is soft enough to be squeezed into the irregularities of the surface, and is held in position by the two parts between which it is placed.

A Gasket for a Cylinder Head is usually made of sheet asbestos, which is frequently combined with wire gauze to give it strength.

The Gasket Shoud Be Carefully Cut to shape and fitted to the bolt holes before applying.

There Should Be No Loose or Frayed Pieces that might project into the cylinder, for these would become white hot from the explosions, and cause preignition.

Loose Threads in the cylinder would get into the valves and prevent them from seating.

Gaskets are also used in the joints of the water circulation system at the water inlet and outlet.

These Gaskets are made of asbestos cloth, or what is more convenient, thin pieces of copper cut to fit, and folded with asbestos in the fold.

This Makes a very Firm Gasket, and one that cannot easily be blown out.

USUAL ENGINE TROUBLES.

An Engine That is in Bad Condition will make a noise that may be distinguished from the noise it makes when running regularly, and the most frequent is a KNOCK, or POUND.

A Knock May Be Due to any of the following causes:

PREIGNITION, described in this instruction.

BADLY WORN OR BROKEN RINGS, or worn piston.

PISTON STRIKING SOME PROJECTING POINT in the combustion space.

LOOSE CONNECTING ROD or wrist pin bearing.

FLYWHEEL LOOSE on shaft ,or with broken spoke.

The Cause for Any Knock should be found at once, and remedied for it may be caused by something that would bend or break the crank shaft or connecting rods if not repaired.

Preignition, if it comes from the carbon deposits of burned lubricating oil, may be remedied by scraping the cylinder and piston.

Worn or Broken Piston Rings should be replaced or reground.

Any Projection in the Combustion Space that is struck by the piston should be removed.

Loose Bearings May Often Be Tightened by taking up on the bolts of the caps, or if too worn for this, the liners may be filed thinner

A Loose Flywheel should be re-keyed, and a broken one replaced.

To Operate an Engine with a loose fly wheel is to run great risk of entirely destroying it.

A Knock Will Also Be Caused by the crank shaft bearings wearing so that the shaft is no longer at right angles to the connecting rod.

PREIGNITION.

It Often Happens that the mixture is ignited before the spark passes ,which is called PREIGNITION.

A Rich Mixture, or the burning of the lubricating oil, will leave a deposit of carbon on the piston head and combustion chamber.

The Intense Heat of the explosons will heat this, and often it will remain glowing until the suction and compression strokes, exploding the mixture before the proper time.

This Deposit may be scraped out, using a steel scraper, and may be prevented by being careful to have the correct mixture.

If the Points of the Spark Plug are too thin and fine, they will get hot enough to glow in the same manner, and in such a case spark plugs with heavier points must be used.

Small Points of Metal, due to rough castings or other causes, must be filed down, using a fine file.

If the Water Circulation Stops, or if the air cooling is not effective. the cylinder walls will get hot enough to ignite the charge, in which case the engine will continue to run after the ignition circuit has been cut off.

The Remedy for This, of course, is to make sure that the engine is properly cooled.

An Engine Gives Its Full Power when the entire charge is correctly ignited, and leaks that allow the pressure to escape reduce the power.

The Most Frequent Cause of Leakage is from pitted valves, which by not closing tightly, permit the pressure to escape.

If the Valves are in Good Condition, and the spark plug and other openings in the cylinder head are tight, leaky piston rings may be causing the loss of compression, and should be examined.

If They are in Good Condition, they will be smooth and shiny, as will also be the cylinder walls.

If the Rings are Dull and Dirty in spots and streaks, it will indicate that the flame passes between them and the walls, leaving a sooty deposit.

Badly Fitting Piston Rings may be caused by the rings sticking in their grooves because of a gummy deposit from the lubricating oil; rings that are stuck in their grooves will not press against the cylinder walls.

Kerosene Oil Will Cut This Gum, and free the rings.

If This is Suspected, a little kerosene poured into the cylinder and distributed by cranking the engine will cure it.

Leakage is Shown by Lack of Compression; that is, there will not be much resistance when the engine is cranked.

After a Little Experience with the engine, it will be easy to notice whether it cranks more easily than it should, and if it does, the reason for the easy compression should be found and removed.

When the Spark Plug or other parts entering the combustion space are not sufficiently tight to retain the compression, the leak may be felt by the hand; washers made of thin copper, doubled over, and the groove filled with asbestos, are very useful in making these connections tight.

A Gasoline Engine Has Always Been a Subject of Ridicule because of its seeming obstinacy in starting and its frequent spells of balking.

The Gasoline Engine Does Not Deserve This Reputation. They are perfectly reliable, if a person understands their construction and how to operate them.

No Doubt if a Novice Attempted to Run a Locomotive the locomotive would soon be a subject of ridicule also.

TROUBLE GENERALLY DUE TO IGNITION.

Most of the Troubles of a Gasoline Engine Are Due to faulty ignition, such as fouled spark plugs or run-down batteries.

LACK OF POWER.

Lack of Power Is Due to either a poor adjustment of the carburetor,which does not mix the air and gas properly, or to a very important subject, that of COMPRESSION.

GOOD COMPRESSION IS NECESSARY FOR A POWERFUL ENGINE.

The Subject of Compression is one of the most important subjects connected with a gasoline engine—if an engine lacks power, nine times out of ten it will be traced to poor compression.

WHAT IS COMPRESSION?

The Compression Space in an Engine Is the Space Between the End of the Piston and the Top of the Inside of the Cylinder.

When We First Draw in a Charge of Gas Into the Cylinder the piston must travel down, but after drawing in the gas through the intake valve, the intake valve is then closed and the piston on its up stroke pushes that gas up into the head of the cylinder and COMPRESSES it.

If the Valve Leaked, or there was a leak otherwise, then the gas would not be compressed to as high a pressure as if there was no leak at all.

When This Gas Is Compressed to the Highest Point, then the spark ignites the compressed gas and forces the cylinder down with great force.

If the Compression Pressure Is Low the force will be less. If the compression pressure is high the force will be greater.

Therefore the Power of an Engine Depends on Good Compression, and good compression **must** be maintained.

THERE ARE MANY PLACES TO LOOK FOR LEAKS.

There Are Many Places to Look for Leaks; through the valves.

not being set right, and open too early or too late, and either lose too much gas or don't get enough in.

There May Be a Sand Hole in the Top of the Piston or in the walls of the cylinder.

There May Be Leaks around the spark plugs.

The Rings May Leak, which are around the piston.

How to Remedy and Prevent All This will be treated under the subject of Repairing.

VALVES MUST BE SET RIGHT.

If the Reader Will Get the Working Model of the Engine and note when the piston just begins to start down on the suction or intake stroke, he will note that the inlet valve begins to open just as the piston starts down.

If the Valve Did Not Open until the piston was, say, half way down, then there would be only one-half a charge of gas drawn into the cylinder, therefore it is important that the intake valve be set so that the valve will begin to open early enough and stay open long enough to get in a good, full charge of gas.

Sometimes Worn Cams and Worn Plunger Rods will prevent the valves from opening exactly at the right time.

HOW TO TEST COMPRESSION.

Although This Subject Should Come Under the Subject of Repairing, I will mention it here because I consider the subject of great importance.

In Illustration, Figure 1, We Have a Compression Gauge which can be secured at any auto supply house.

This gauge is screwed into a spark plug hole.

The Next Operation Is to Crank the Engine, and the top needle will push the lower needle to the highest point and leave it there; in other words, the top needle will come back to zero, but the lower needle will stay fixed at the highest part and this will show the compression of that cylinder.

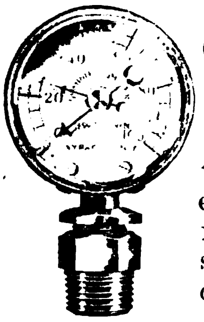
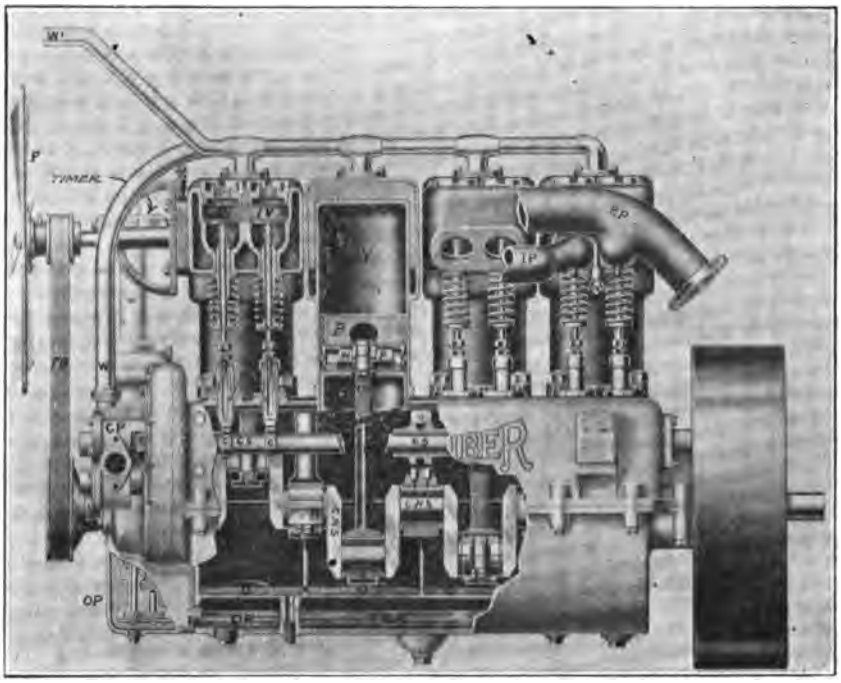


Fig.

The Next Cylinder Is Tested in a Like Manner, and so on.

A Record Is Kept of the Pressure in Each Cylinder, and if one or more of the **cylinders** lack pressure, then the cause should be investigated and remedied, because that cylinder or cylinders with low compression is not doing the work it ought.



Study of a Modern Four-Cylinder Gasoline Engine.

Cylinders. Single, cast in pairs, "L" type.

Valves. Mechanically operated, all on one side.

Ignition. Any jump spark system; coil or magneto.

Fuel System. Gasoline.

Carburetor. Any make of Carburetor.

Lubrication. By pump "OP" from oil reservoir "OR." Oil reservoir is operated from the bottom of crank case. Note oil stands in bottom of crank case at "O". The connectiong rod picks the oil up when on its lowest stroke.

EV Exhaust valve (mechanically operated).

IV Intake valve (mechanical).

CY Cylinder, cast singly, "L" type—all valves on one side.

P Piston. Shown cut in half.

WP Wrist pin.

CR Connecting rod.

PR Plunger rod.

C Cam for lifting valve.

CS Cam shaft (broken to show connecting rod) which runs through Engine and is operated by the gear on front of Engine on crank shaft.

CKS Cam shaft, 180 degree crank shaft.

W Water pipes. WI connects with the top of radiator. Lower end of radiator connects with circulating pump at CP.

EP Exhaust pipe. A pipe leads from this to muffler and discharges the gas to rear of car (only part shown).

IP Intake pipe (only part shown.) Intake pipe connects underneath the exhaust pipe.

CP Cylinder pump for forcing water through water jacket and radiator Pump is geared tol gear or crank shaft.

F Fan.

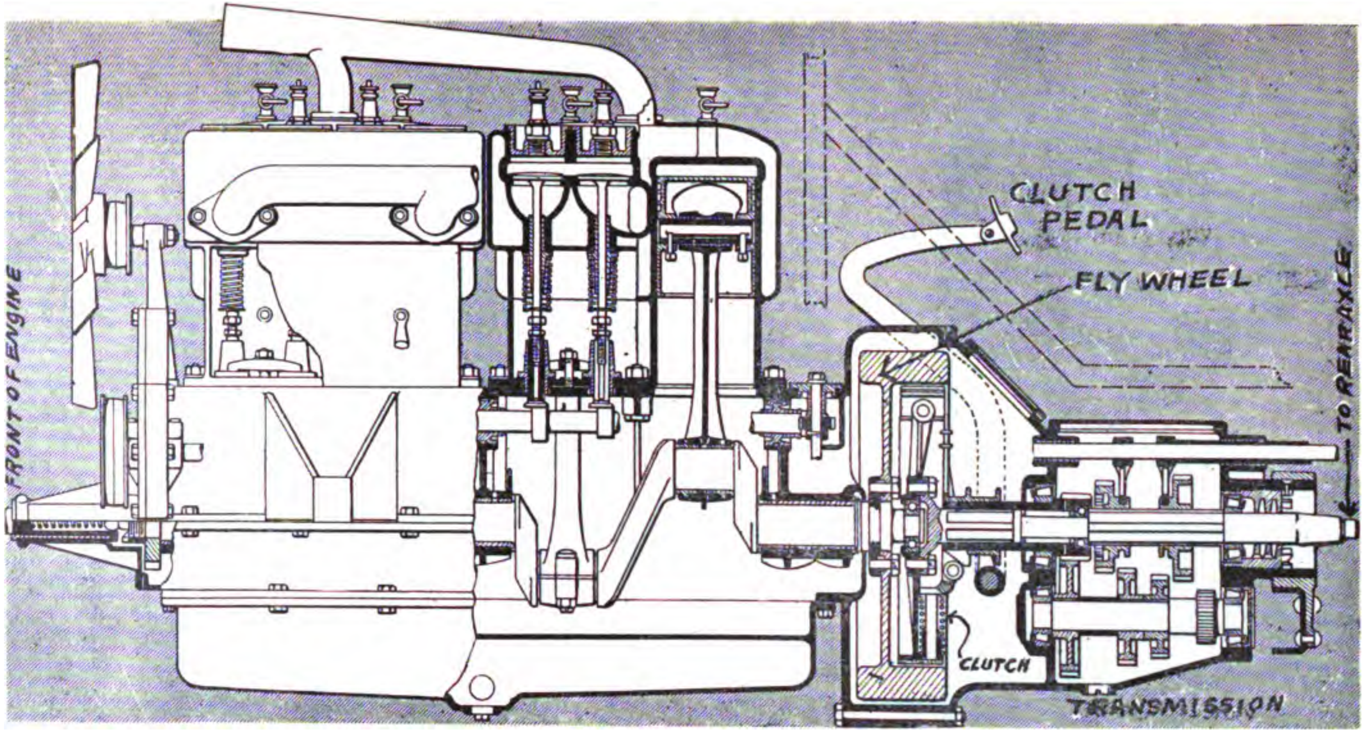
FB Fan belt.

TIMER The timer sets upright on the Engine It is driven by a bevel gear from the cam shaft.

OR Oil reservoir. Note this is underneath crank case and is a seperate compartment.

OP Oil pump. This pump is operated by Engine and forces oil from oil reservoir to carburetor, and the oil is used over and over again.

CHART No. 48.

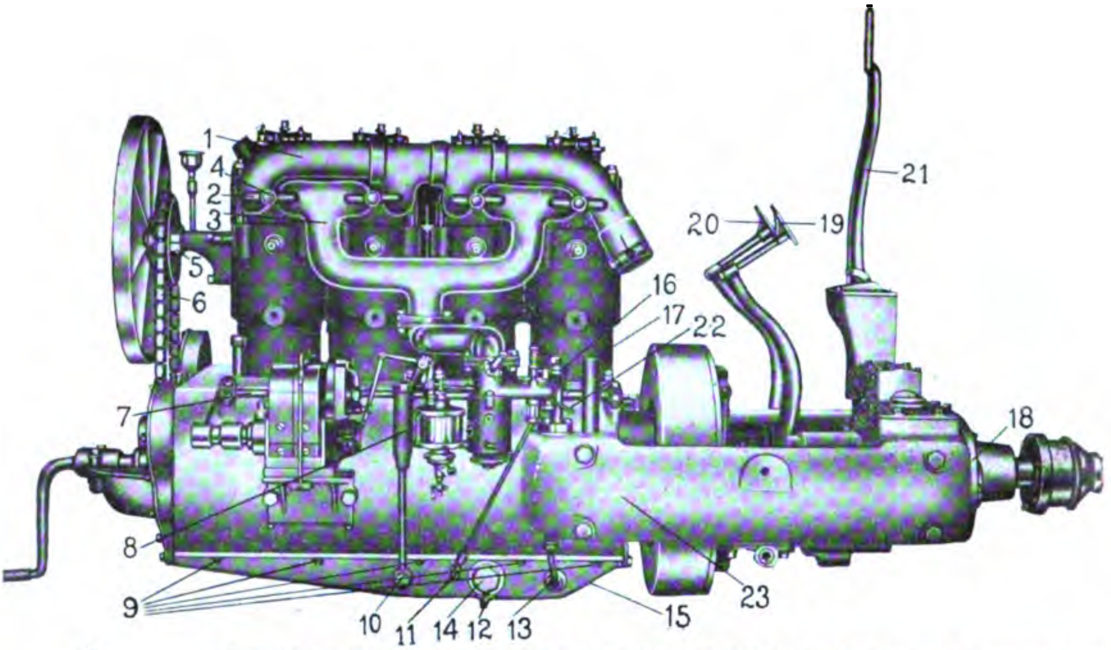


A Modern Power Unit, consisting of Engine, Clutch and Transmission coupled together and constructed in a single unit ready to hang in the frame.

Engine. Four cylinder. Cylinders cast in pairs. Valves (exhaust and intake) mechanically operated and all on one side of the Engine. This type of cylinder is called the "L" type. The ignition is usually of the 'Dual" system—meaning a high tension magneto and a coil and battery, either of which may be used on one set of spark plugs.

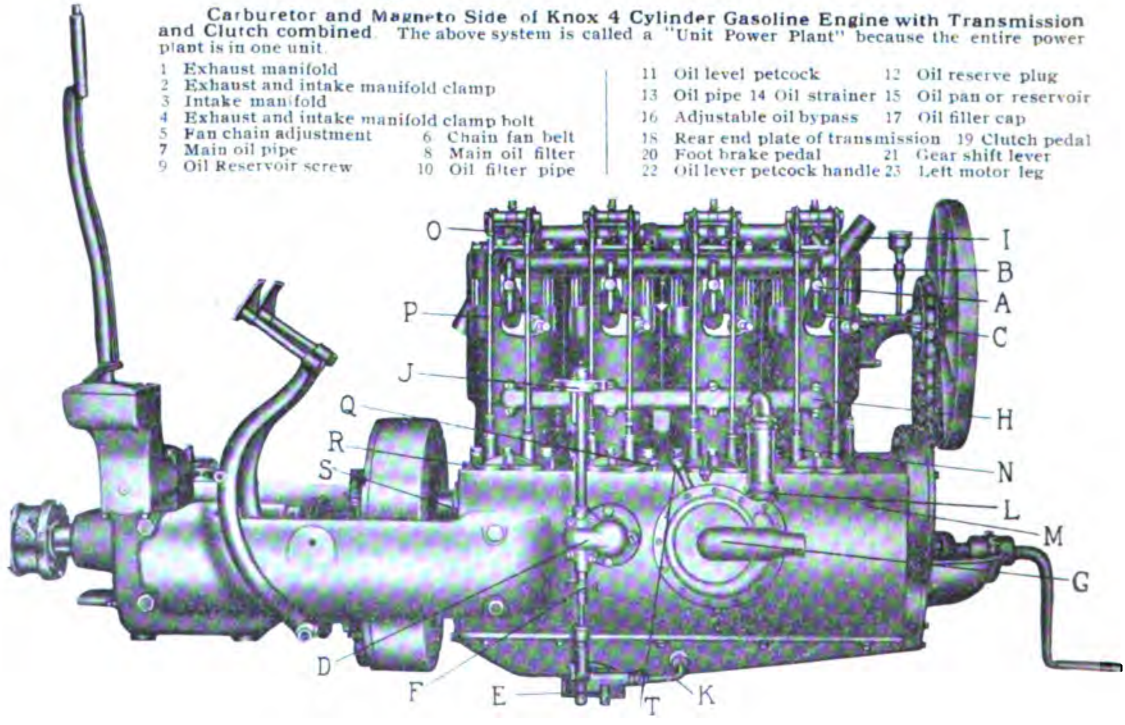
Clutch. Internal expanding type. The multiple disc type of clutch is also a popular form, and quite frequeutly the cone type is used. The cone type is used more often when the transmission and Engine are in two seperate parts.

Transmission. Selective gear type contained in gear case. Gear case is bolted to the Engine case over housing of fly wheel.



Carburetor and Magneto Side of Knox 4 Cylinder Gasoline Engine with Transmission and Clutch combined. The above system is called a "Unit Power Plant" because the entire power plant is in one unit.

1 Exhaust manifold
2 Exhaust and intake manifold clamp
3 Intake manifold
4 Exhaust and intake manifold clamp bolt
5 Fan chain adjustment 6 Chain fan belt
7 Main oil pipe 8 Main oil filter
9 Oil Reservoir screw 10 Oil filter pipe
11 Oil level petcock 12 Oil reserve plug
13 Oil pipe 14 Oil strainer 15 Oil pan or reservoir
16 Adjustable oil bypass 17 Oil filler cap
18 Rear end plate of transmission 19 Clutch pedal
20 Foot brake pedal 21 Gear shift lever
22 Oil lever petcock handle 23 Left motor leg

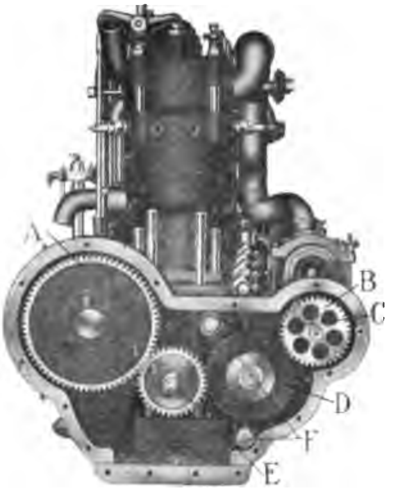


Valve Side. Exhaust and Intake Valves are both mechanically operated. A sytem of overhead rocker arms for both Intake and Exhaust. See Chart 38 for explanation of various types of valves.

A—water manifold clamp bolt, B—water manifold clamp, C—outside water connection, D—oil pump and ignition timing gears, E—oil pump. F—oil pump spring catch, G—water pump, H—intake water manifold, I—return water manifold J—ignition timer, K—oil pipe, L—hose clamp, M—Front cam shaft bearing screw, N—Valve lifter, O—Push rod adjustment, P—Valve push pad, Q—center cam shaft bearing screw, R—Rear cam shaft bearing screw, S—rear cam shaft bearing cap T—water pump grease cup.

Study of a photograph of a 4 cylinder, 4 cycle Engine with mechanical intake and exhaust valves—"overhead type" as shown in Fig. 4A, Chart 38. The clutch, transmission levers and pedals are attached to Engine crank case

CHART No. 49A.

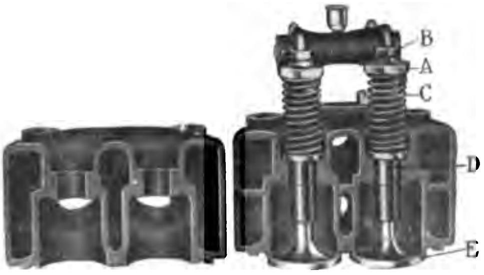


End View of Engine shown in Chart No 49A—showing the gears. Gear E measures 4 inches, gear A measures 8 inches.

A—is the cam shaft gear (all valves on one side).
E—Drive gear on crank shaft.
D—Idler gear between drive gear and gear operating the magneto.
B—Magneto gear.

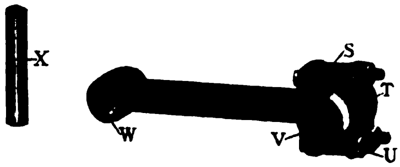
The Cam Shaft Gear runs one-half the speed of the crank shaft.

The Magneto Gear runs the same speed as crank shaft

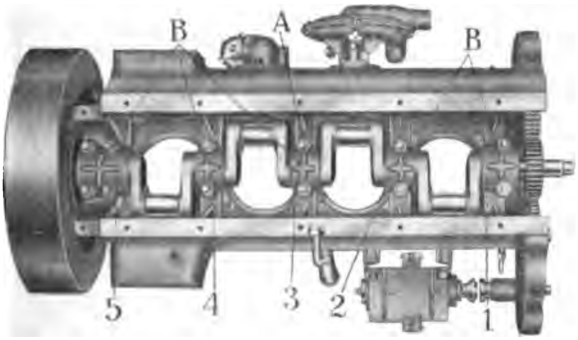


Cylinder Head showing intake and exhaust valve side by side, also shows how the push rods operate the overhead rocker arms.

A—Valve spring cap nut, B—Valve spring cap lock nut, C—Valve spring, D—Valve stem guide, E—Valve stem.

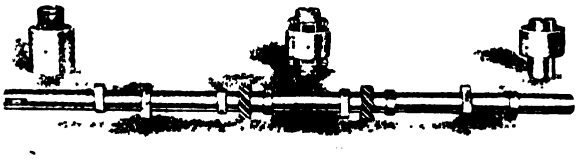


Connecting Rod. S—connecting rod shims, T—Connecting rod bearing cap, U—Connecting rod bearing cap nuts, V—Connecting rod bearing, W—Piston pin bushing, X—Piston pin.



Crank Case of Engine showing main bearings and crank shaft in its bearings:

1—Front crank shaft bearing.
2—Second crank shaft bearing.
3—Crank shaft bearing.
4—Crank shaft bearing.
5—Flywheel crank shaft bearing.
A—Crank shaft bearing cap nut.
B—Main bearing cap.



Cam Shaft which runs through the Engine and is operated by Gear E and A—see end view above. The cams on this shaft lift the valves—see another view of cams in Chart 35. The bearings of the cam shaft are shown to one side of the Cam Shaft.

Study of the Parts of an Engine from Photographs.

CHART No. 49B.

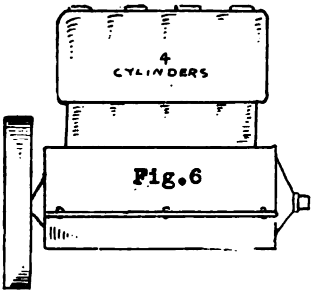


Fig. 1.

Cylinders cast "Enbloc"—all together.

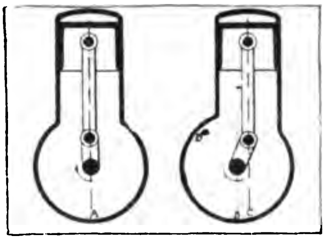


Fig 2.

Central and Offset Crankshafts.

Note difference with offset cylinder and cylinder located over crank shaft.

Cylinders are sometimes cast singly, in pairs and "enbloc", the latter meaning all four cast together.

The Offset Cylinders (Fig. 2), a motor with an offset crank shaft or offset cylinders as you choose to say, is represented. The line A which passes through the center of the cylinder is some distance to one side of the line B which passes through the center of the crank shaft. Some of the advantages claimed for the offset crank shaft are less liability of a back kick, reduced wear on the bearing surfaces of the cylinder walls, connecting rods and crankshaft, less liability of the motor to be stalled, when the car is running slowly on a high gear, and other constructional facilities.

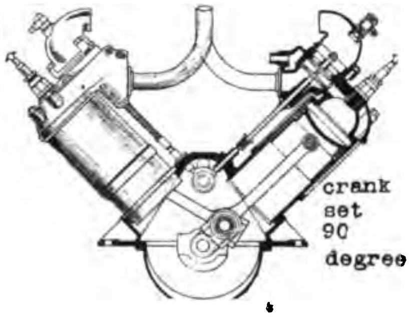


Fig. 3.

"V" Type of Engines—Type used on Aeroplanes.

In the "V" Engine (Fig. 3), the pair of cylinders are set at an angle, generally between 45 and 90 degrees, both cylinders being in the same plane. This makes it more economical of space than having the cylinders side by side, and it is adopted to some extent on aeroplanes, mainly for the reason of getting more power on crank shaft and economy of weight. Thus two cylinders can be fixed in the space occupied by one, four in the place of two, and eight in the place of four. In principle the operation is this; Both connecting rods drive on to one crank as shown. If one cylinder is on the inlet stroke the other will be compressing. Before the inlet stroke of one is complete the other cylinder will fire, so that the opposing cylinder has still parts of its suction stroke to complete, and then compression takes place Meanwhile the other cylinder is exhausting. It will be followed from this that the strokes of the two cylinders slightly overlap.

CHART No. 50.

THE STATIONARY GASOLINE ENGINE.

Stationary Gasoline Engines differ from the type of engine previously explained, only in a few minor details. (See Chart No. 51A.)

The Principle of operation is identically the same.

The Stationary Engine is Built large and heavy.

A 10-H. P. Stationary Engine must have a much larger cylinder than a 10-horse power automobile engine.

The Reason for This is that the speed of a stationary engine is much slower. IT RUNS SOMETIMES FOR NINE HOURS AT THE TIME and if it was as high a speed as the automobile engine that only runs at its highest speed only for short distances and not steady, the stationary engine running regularly all day under full load would soon wear out, therefore the cylinders are made larger and the speed slower in order to get the same relative amount of power.

Weight and Bulk Makes no Particular Difference in a Stationary Engine but it makes considerable difference in an auto engine.

IGNITION FOR STATIONARY AND MARINE ENGINES.

Some of the Old Style stationary engines have the old hot tube system of ignition but is rapidly being replaced with electric ignition and you seldom find the hot tube in use any more.

The Ignition in General Use is the Low Tension "Make and Break" style described under the subject of ignition further on.

Modern Stationary Engines use the "jump spark" system of ignition, described further on.

The Principle of the Engine Described Previously is so similar to this type, in actual operation, we do not deem it necessary to treat the subject in detail for if the reader has clearly mastered the principle of the former, then he will understand all types of engines. THE MAJORITY OF STATIONARY ENGINES ARE OF THE FOUR CYCLE TYPE.

MARINE ENGINES.

The Boat or Marine Engine of old design is of the 2 cycle type and is equipped with the low tension "Make and Break" system of ignition.

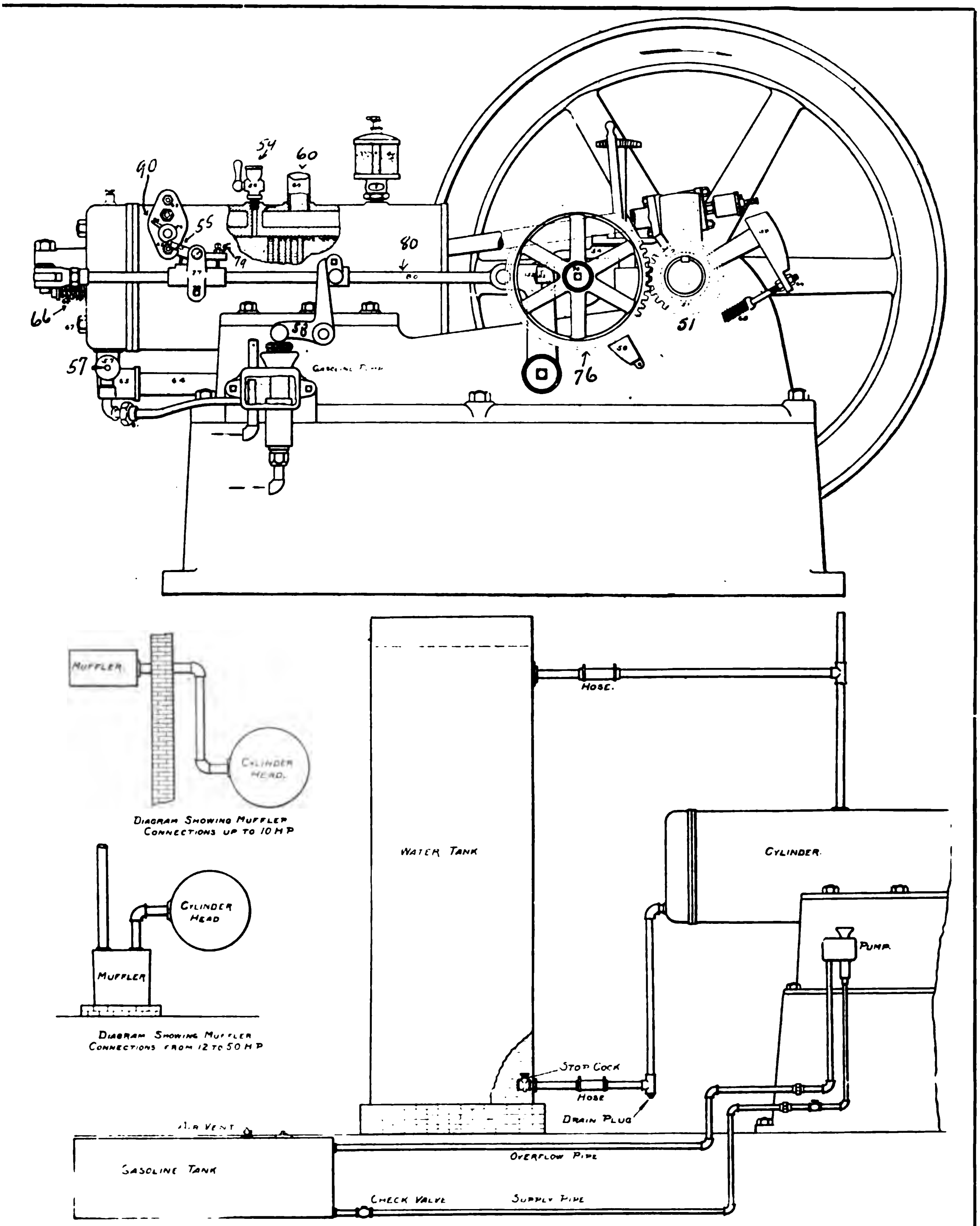
The Modern Type is of the four cycle type and equipped with "high tension" or "jump spark" ignition.

The Marine Engine differs only in being built heavier and operated usually at one speed when of the 2 cycle type and low tension ignition.

The Modern Engine, however, is capable of being operated at VARIOUS speeds when of the four cycle type and high tension ignition.

The subject of ignition will be treated thoroughly further on and will cover all types of engines.

Stationary Engines sometimes have governors. See explanation of governors in Chart 40.

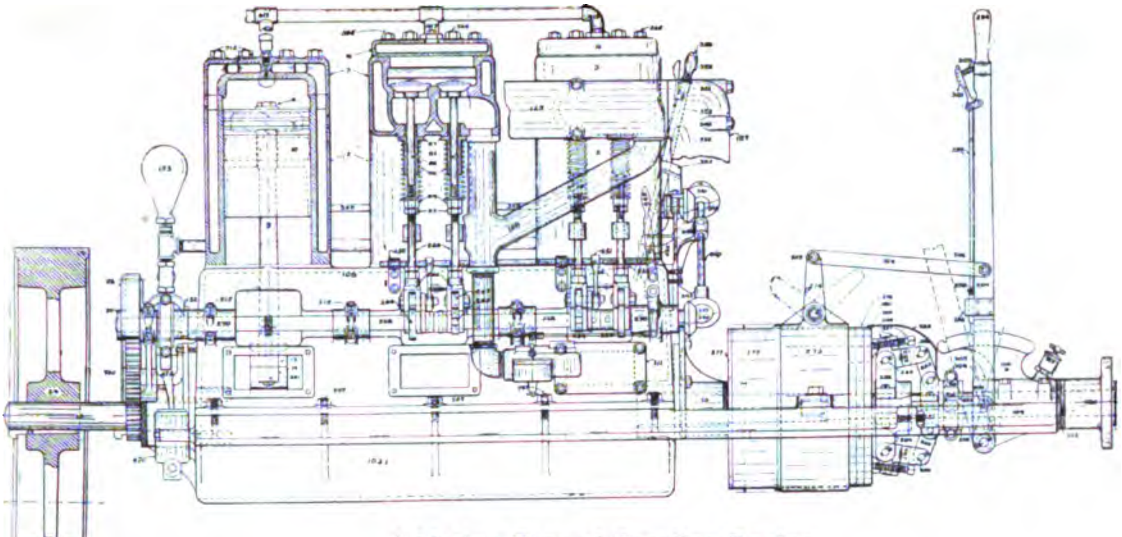


66 Admission Inlet Valve. 67 Cylinder Head Studs.
57 Carburetor. 64-65 Air Pipe. 60 Water Pipe.
59 Priming Cup. 77 Igniter Trip.
55 Igniter Trip Dog. 79 Adjustment of Igniter.
90 Igniter Trip Lever. 66 Igniter Sleeve.
62 63 Studs. 50 Part of one of the Governor Weights.

58 Rocker Arm Operating Gasoline Pump.
80 The Detent Rod Works Forward and Backward.
53 Catch Pin.
76 Gear Running Half the speed of Engine and Operates Valves and Igniter.
77 Exhaust Valve on Opposite Side of Engine.

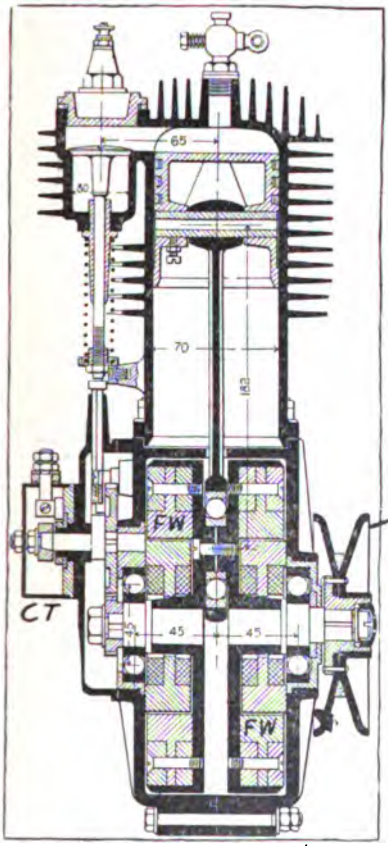
Description of a Stationary Gasoline Engine.

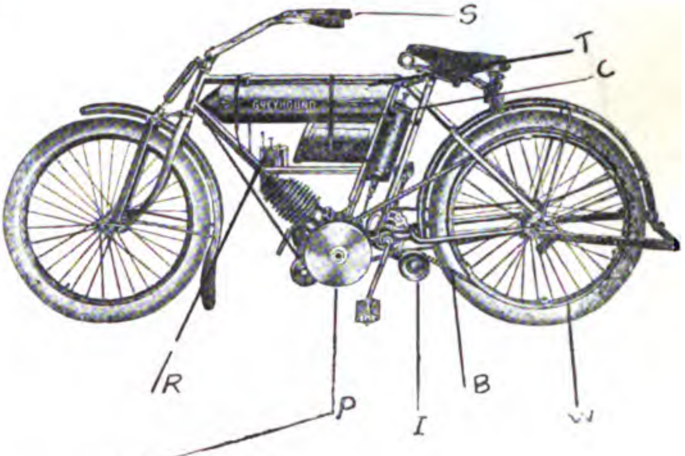
CHART No. 51A.



A Marine Type of Gasoline Engine.

With reverse gear and clutch. A lever for operating the clutch and reverse gear attached.





R—Carburetor, P—Pulley, I—Idler to tighten belt, B—Belt, W—Wheel Pulley, C—Spark Coil, T—Gasoline Tank, S—Switch in handle bar.

The Motor Cycle.

The Motorcycle is operated by a Gasoline Engine.

The Motorcycle was the first real self-propelled vehicle by a gasoline motor. Daimler of Germany, in 1885, perfected the first gasoline Engine, and attached it to a 2-wheel bicycle.

Kerosene was used instead of gasoline.

The Motorcycle Engine

is operated just the same as any other four-cycle type of gasoline engine.

The fly wheels are sometimes placed inside of the crank case as shown in Fig. 7. This saves space and weight and makes the engine more compact

FIG. 7

A Motorcycle Engine.

F W—Fly Wheel, C T—Commutator or timer, 183—Center of piston pin to wrist pin, 65—Combustion Chamber, 30—Valve Chamber, 70—Cylinder Wall, 45—Crank shaft with fly wheels inside of crank case, fly wheels are counter balanced.

Note—Drive Pulley on end of crank shaft outside of crank case.

CHART No. 51B.

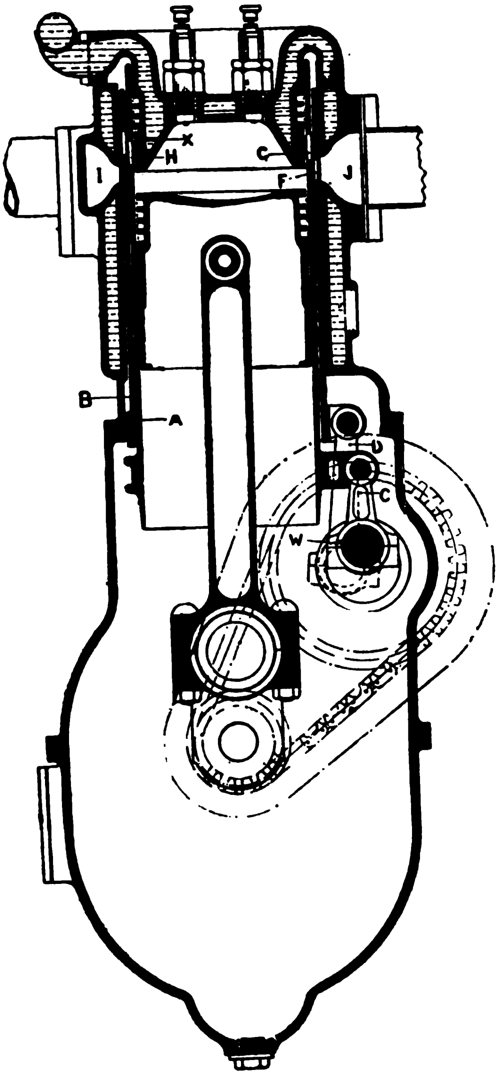


Fig. 1.

Sectional diagram of exhaust stroke completed, and inlet ports in sleeves about to register with the port (I) in cylinder. Exhaust ports are in closed position. For clearness in the diagram the sleeves are not shown closely fitting as is actually the case in practice.

Several makes of foreign cars are now using this engine and it is being adopted by the "Stearns" and "Columbia" in America.

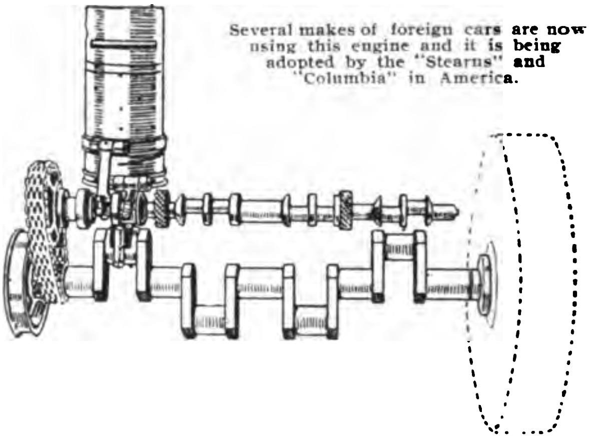


Fig. 2.

Diagram showing crankshaft and slide operating shaft driven by chain. The parts of the other three cylinders omitted are exactly similar to the one shown. The lubricating holes in outer slide, and lower end of spiral oil groove on inner side, are visible.

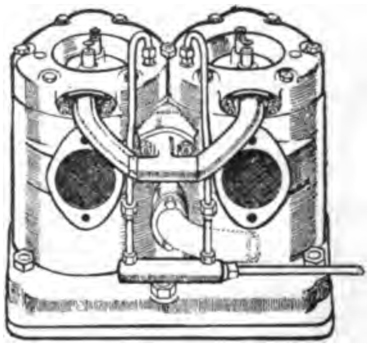


Fig. 3.

Exterior view of two cylinders with exhaust pipe disconnected and showing independent water circulation for combustion heads. The small pipes convey oil to the cylinder heads and sleeves. The combustion heads are detachable from the cylinders. The large area of the exhaust ports will be noted.

Explanation of the Knight Slide Valve Engine.

The main principle of this engine (made under Knight's patent) is the substitution of sliding valves for the usual poppet or tappet valves. The sliding valves consists of two concentric shells or pistons of cast iron accurately turned, working in between the driving piston and the cylinder walls. These shells have two series of large area ports or slots cut in the upper ends, which register together at the required instant in the respective strokes of the piston. One pair of slots form the inlets and the other pair the exhausts. The sliding shells of each cylinder, which have a relatively short stroke, about 1 inch, are driven by two short connecting rods or side arms working off a lay crankshaft, the cranks having a very small throw, which takes the place of the usual camshaft in the tappet valve form of engine.

This valve-operating shaft rotates at half the speed of main crankshaft. The sliding shells extend right up into the deep cone-shaped combustion head, which is a detachable unit. This head is of a special design, insomuch that it is provided with a set of piston rings, three narrow and one double, the latter being specially wide and termed the compression ring. These rings prevent any escape of pressure in an upward direction, whilst the usual set of three rings on the working piston maintain pressure tightness in the lower direction.

A pair of sparking plugs for dual storage battery and magneto-ignition are fitted direct in the combustion head.

The lubrication of the sliding shells is effectively maintained by spiral oil ways on the surface and numerous holes drilled through, which direct the oil thrown up by the crank, on the usual splash principle, to the working surfaces.

The working details of this engine can be readily followed by reference to the appended diagrams. One shows a vertical section. The two sliding shells encirling the working piston are at A and B. At the top on the left is the inlet port (I), with inlet slots (H) almost in register.

Opposite is the exhaust port with slots (G and F), in the "shut" position.

The short connecting rods giving a sliding movement to the two shells, by means of side lugs, are shown at D and C; whilst W is the special crankshaft off which they work. Fig. 2 shows the disposition of main crankshaft, the layshaft, and the sliding valves for one cylinder. The layshaft is driven by a chain instead of the usual two-to-one gear wheels.

The various throws on upper shaft are shown, whilst the two skew gears are for driving the ignition magneto, distributor and water circulation pump.

By the elimination of the usual tappet valves a very smooth and noiseless action is obtained, and the large ports in the slides give the utmost freedom to the inlet and exit of the gases, resulting in an increase of flexibility.

The total absence of pockets and projecting parts in the combustion chamber avoid all pre-ignition risks, and give a very high fuel efficiency

A high compression is obtainable without risk, although, in practice, 80lb. is not exceeded.

The combustion head, it will be seen, is amply water-jacketed, the water space being self-contained and not depending on a joint. It attaches to the cylinder by a well surfaced joint, kept in close contact by a series of bolts passing through the head into the cylinder casting. The engine is, as a whole, considerably simpler, neater in exterior appearance, and lighter than the ordinary type, and all working parts are enclosed and thoroughly lubricated.

An independent supply of oil is carried direct to the lower part of the cylinder walls.

A Different and New Valve Principle of Gasoline Engine, the Knight.

CHART No. 51C.

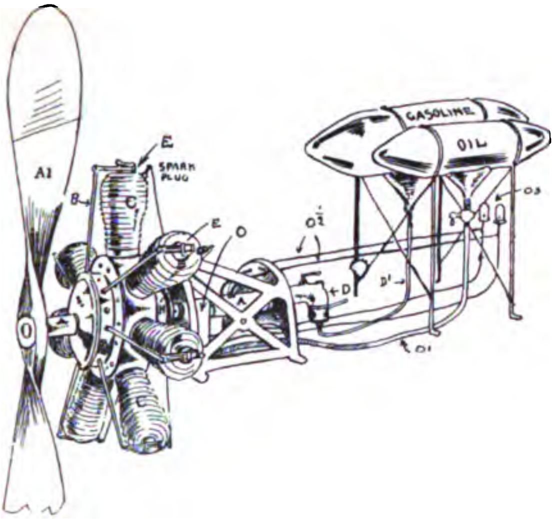


Fig. 1—The Gnome Engine complete Power Plant with Aeroplane Propellor Attached.

The Gnome Aerial Engine is somewhat different from the average engine. Referring to Fig. 1, the 7 cylinders "C" are attached to a crank case in the usual manner. The cylinders and crank case revolve while the crank shaft remains stationary.

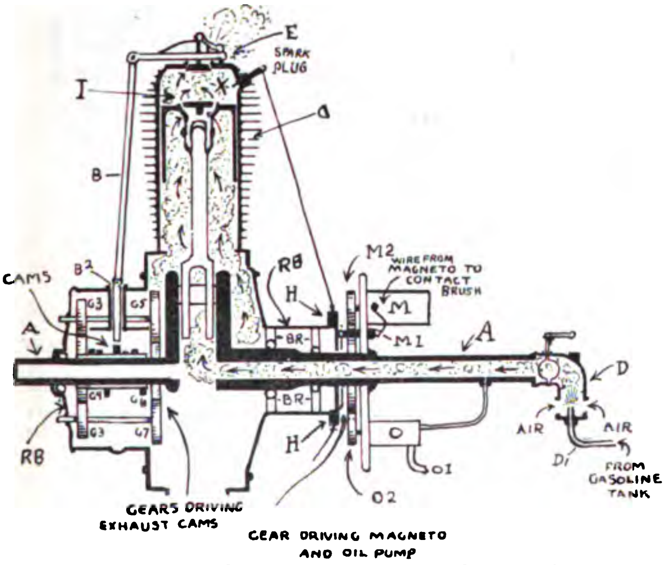

E
SPARK PLUG
I
a
B
CAMS
B2
G3
G5
A
RB
H
M2
WIRE FROM MAGNETO TO CONTACT BRUSH
M
M1
BR
A
D
AIR
AIR
D1
FROM GASOLINE TANK
O
O1
O2
H
G4
G6
G3
G7
RB
GEARS DRIVING EXHAUST CAMS
GEAR DRIVING MAGNETO AND OIL PUMP

Fig. 2—Showing Carburetor Intake through Crank Shaft.

The crank shaft A is hollow tubing. Gas from carburetter passes through the shaft to crank case. It is then drawn into the combustion chamber through the head of the piston, Fig. 3.

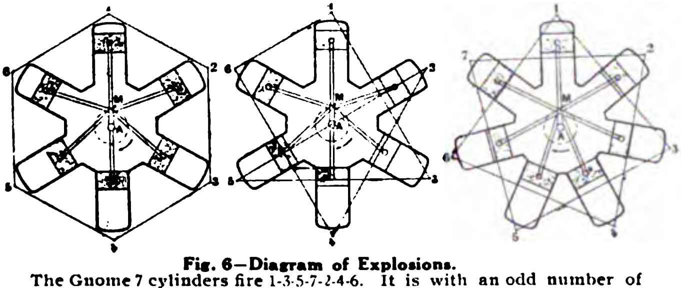


Fig. 6—Diagram of Explosions.

The Gnome 7 cylinders fire 1-3-5-7-2-4-6. It is with an odd number of cylinders that the explosions can be obtained at equal distances.

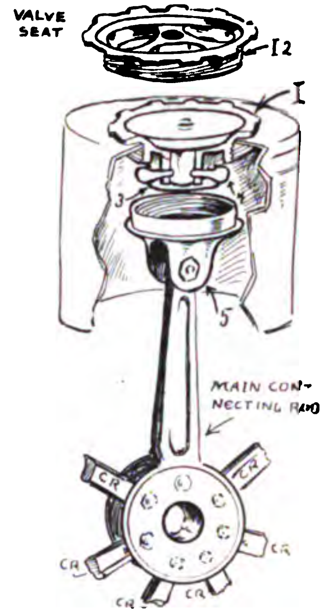


Fig. 3—Piston.

The gas passes through an automatic valve in the head of the piston, see Fig. 1. It is the valve seat which screws into head of piston. There is one main connecting rod to which is attached the other 6 connecting rods as shown.

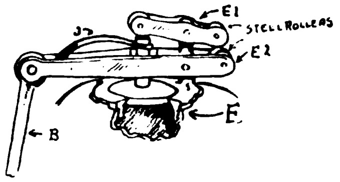


Fig. 4.—Exhaust Valve.

Shows illustration of the overhead mechanical exhaust valve. The exhaust is expelled from out this valve out of top of cylinder.

B. tappet rod; E. exhaust valve cage, which screws into head of cylinder; E2, main rocker arm; E1, secondary rocker arm; 3, flat spring.

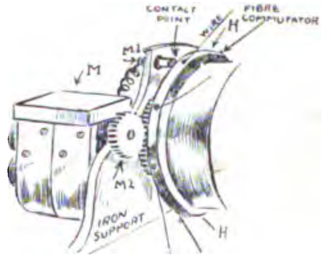
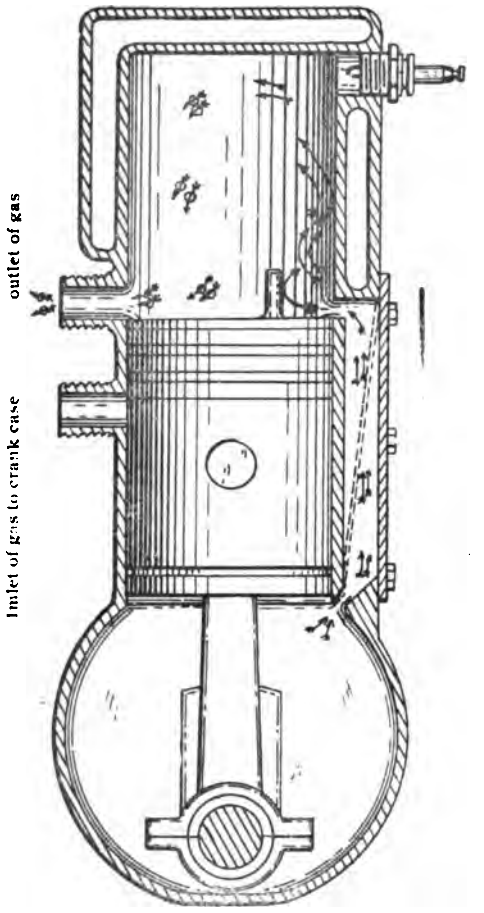


Fig. 5. Magneto Ignition.

The ignition is by means of a high tension magneto. The distributor instead of being on the magneto is a fibre disc attached to crank case with 7 equally divided parts of contact. The plug "contact point" in Fig 5. and M1 in Fig. 2 is the insulated plug which carries the electricity from the magneto to the distributor.

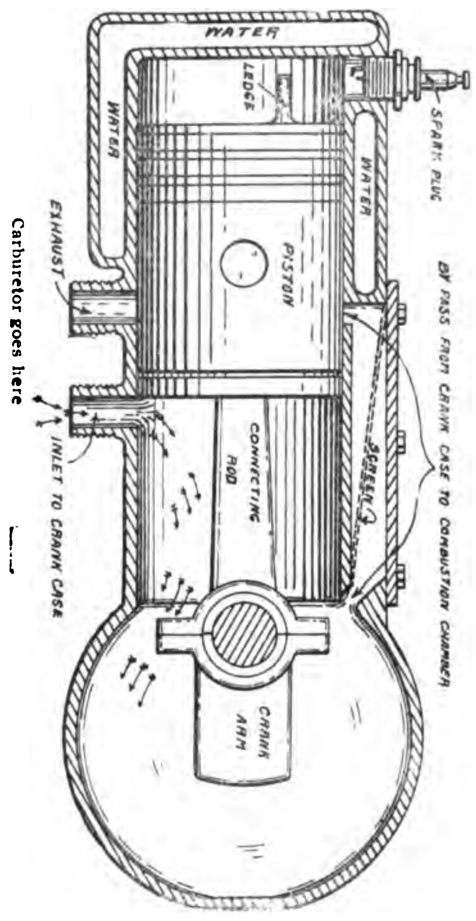
The Gnome 7 Cylinder Revolving Motor. Made especially for Aeroplane propulsion. This type of engine is a revolving type, overhead mechanically operated exhaust valve and automatic valve. High tension magneto ignition.

CHART No. 51D.



The Piston of a 2-Cycle Engine does not draw gas to the cylinder through valves in the head of the cylinder.

Fig. 1 shows piston on down stroke—fresh gas is being drawn in on the right from the crank case and the burnt gas is being discharged to the left. Therefore we have the **Intake and Exhaust Stroke** simultaneous.



After the Gas has passed through the "bypass" from crank case to head of cylinder, through the screen, the piston on the up **stroke compresses** the charge and it is immediately ignited and we have the **explosion stroke** down. Therefore we have **but two strokes;** the **compression and explosion stroke** and both during one revolution of the **crank shaft**.

Explanation of the 2-Cycle Engine.

A 2-Cycle Engine is one in which there is an explosion in each cylinder each revolution of the crankshaft. **In the 4-Cycle Engine** there is an explosion in each cylinder every other revolution. **The word 4 cycle gets its meaning** from the fact that on the down stroke of the piston the mixture is sucked into the combustion chamber, on the up stroke this mixture is compressed to say 70 pounds per square inch; on the next down stroke this compressed mixture is exploded, and on the next upstroke the burnt gases are exhausted or driven out into the muffler. **These are the four cyles of the 4-cycle motor, namely, suction, compression, explosion and exhaust. It requires two revolutions of the crank shaft to complete this cycle.**

In the 2-cycle motor, as the name suggests, these are cut in half. **On each down stroke** the exhaust gases are freed, and the intake gases drawn into the cylinders, the exhaust escaping at one side and the mixture entering the other, so that the entrance of one helps the escape of the other. **On each up stroke** there is the usual compression. **Some 2-cycle Engines are made** without valves of any nature, there being a port or opening on one side of the cylinder for the exhaust and another on the opposite side for the intake, and these ports are covered and uncovered by the movement of the piston. **The piston generally carries a vertical fin or baffle plate** on the head which directs the flow of the intake gas towards the top of the cylinder so that it helps to drive out the exhaust gases.

CHART No. 51E.

INSTRUCTION No. 11.

TWO CYCLE ENGINES.—Principle of the Two Cycle Engine.

In These Instructions on Engines, only four-stroke-cycle engines have been considered, as that type is the one most largely in use.

Another Type, used on the Elmore and Atlas automobiles, but generally for motor boats, is called the TWO-STROKE-CYCLE, or for short, TWO-CYCLE.

In the Four-Cycle Engine, four strokes are necessary; to draw the gas into the cylinder, compress it, make the power stroke, and exhaust the burned gas.

In the Two-Cycle Type, this is done with two strokes, Chart 52F showing its construction.

It Has No Valevs, the gas being admitted and exhausted through PORTS.

A Port Is an Opening Into the Cylinder that is opened or closed by the piston sliding past it.

The Crank Case of a Two-Cycle Engine Is Air Tight, and the mixture is drawn into it and from there passed to the cylinder, instead of being drawn directly into the cylinder as in the four-cycle type.

There Are Three Ports in the Cylinder Wall; one connected to the inlet pipe, one connecting the crank case and cylinder, and one connected to the exhaust pipe.

When the Piston Is at the Top of Its Stroke, as shown in Chart 52F, it closes the exhaust port, as well as the port connecting the crank case and cylinder, but uncovers the inlet port.

By the Inlet Port, the mixture passes from the carburetor to the crank case, and fills it.

When the Piston Slides Downward, the inlet port is closed and the mixture in the crank case, not being able to escape, is compressed.

It Is More and More Highly Compressed until the BY-PASS port is opened by the piston sliding past it, when the compressed mixture passes to the combustion space of the cylinder.

When the Piston Has Slid Outward enough to open the by-pass port, it also uncovers the exhaust port, which is on the other side of the cylinder from the by-pass port.

When the Exhaust Port Is Open, the burned gases escape through it, and the fresh charge entering is prevented from crossing the cylinder and also escaping, by a ledge on the piston head, which shoots the fresh charge to the upper part of the cylinder.

The Fresh Charge That Enters, in being turned to the upper part of the cylinder, helps to push out the burned gases fro mthe previous explosion, and takes its place.

The Fly Wheel in Turning sends the piston to the top of its stroke, which compresses the charge, and at the same time uncovers the inlet port, admitting more of the mixture to the crank case.

The Spark Explode sthe Charge When the Piston Is at About Its Highest Point, and the piston in moving downward again uncovers the exhaust and by-pass ports.

Thus There Is an Explosion Every Revolution, or Every Two Strokes, which is twice as often as is the case with a four-cycle engine.

The Power Stroke Is Also the Exhaust and Compression Strokes, for while one end of the piston is being acted on by the explosion, the other end is compressing the charge in the crank case.

While It Is a Great Advantage to Have Such Constant Explosions, it is not possible to get as high compression as with a four-cycle engine, for the ports are open for so short a time that all of the burned gas cannot escape, nor can a full charge be taken in.

Besides the Greater Number of Explosions, which produce a steady pull on the wheels, a two-cycle engine has the advantage of being free from valve trouble, as there are no valves to warp or pit, and no valve operating mechanism to wear.

A Two-Cycle Engine Thus Has Advantages and Disadvantages as compared with a four-cycle, and its choice for automobile work is largely a matter of preference.

It Is Not as Efficient, or as economical of fuel as the four-cycle type, but the absence of valve trouble is a sufficient advantage to have many people adopt it.

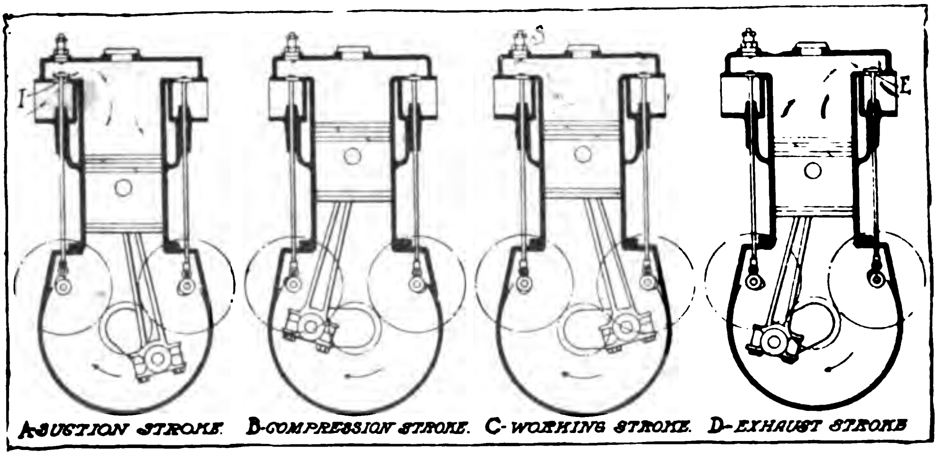
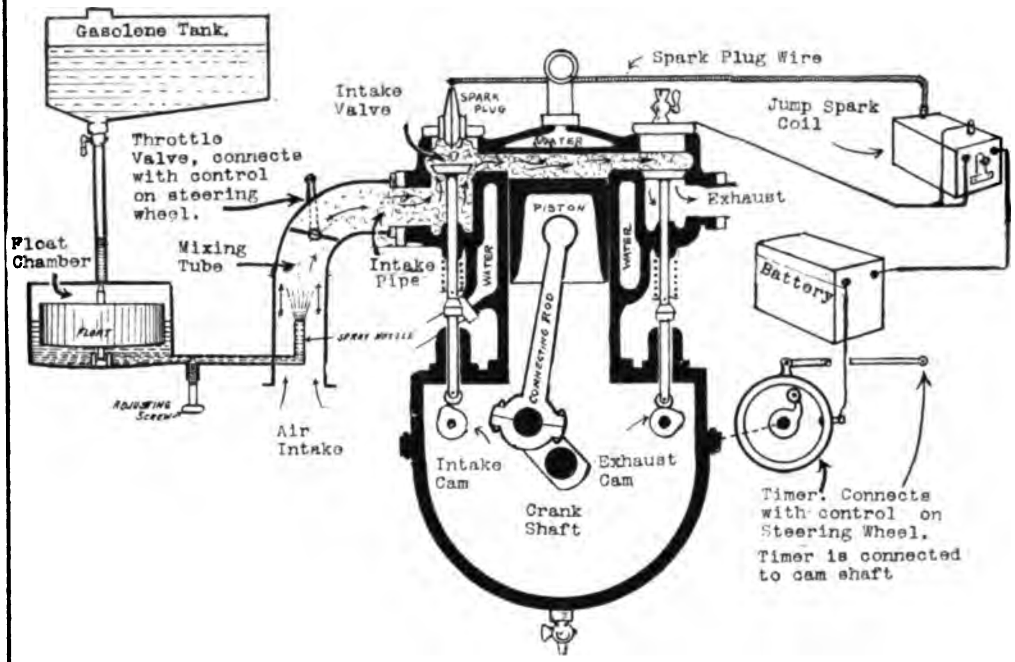


FIG. 2—DIAGRAM SHOWING OPERATION OF A FOUR-CYCLE ENGINE

Diagram showing operation of the Four Cycle Engine, for comparison with Two Cycle Engine on Chart 47.

In the **Four Cycle Motor,** as stated above, there are four strokes of the piston to every explosion or power impulse, or one power impulse to every two revolutions of the fly wheel. At A in Fig. 2, the piston is descending on the intake stroke, the inlet valve I is open and fuel is flowing into the cylinder; this continues until the piston reaches the bottom center. As the piston begins to rise on the next stroke, B, the inlet valve closes, both valves remaining closed while the fue is compressed. Passing the top dead center, as at C, the compressed gaseous mixture is ignited by a spark from the spark plug S and combustion takes place, the heat of which creates an expansive force that drives the piston downward. Before the piston begins to rise on the fourth or exhaust stroke D the exhaust valve F opens and remains open until after the piston begins to descend again on the intake stroke.



How the Carburetor Works.

The gasoline flows from the gasoline tank to the float chamber of the carburetor through a small brass or copper pipe.

The float chamber immediately fills up until the float (made of cork or hollow copper or brass) rises and cuts off the flow.

The level of the gasoline in the float chamber is practically level with the end of the spray nozzle which extends into the mixing chamber. This mixing chamber is connected to the intake pipe of the Engine.

If the throttle valve is now opened and the Engine is cranked the piston will draw in the gasoline, mixed with air, through the inlet valve (the inlet valve cam raises the inlet valve on the suction stroke).

After the gas is drawn into the cylinder the inlet valve closes, and on the next upward stroke of the piston as the gas cannot get out of the cylinder it is **compressed,** then **ignited** by an electric spark. When the compressed gas is ignited by the spark the gas explodes and the force of the explosion forces the piston down.

After the piston reaches the bottom of this explosion or power stroke the exhaust valve begins to open just as the piston starts up again, and the burnt gas is forced out. This is called the exhaust stroke.

The same operation is again repeated and the momentum of the fly wheel keeps the Engine in motion until the next "power or ignition stroke."

The speed of an Engine is varied by opening and closing the throttle valve.

CHART No. 52.

INSTRUCTION No. 12

CARBURETION.—Gasoline. Carburetion. Carburetors: Side Float Type, Concentric Type, Governor Type. Venturi. Speed Control. Carburetor Construction. Carburetor Adjustments. Gravity Feed and Pressure Feed Systems. Intake Manifolds.

The Mixing Together of Gasoline Vapor and Air is called CARBURETION, and the device that keeps the two in proportion is called a CARBURETOR.

To Get Energy Out of the Gasoline it is necessary for it to be converted into a vapor and then be mixed with a large volume of air before it can be exploded in the cylinder.

There Are Two Ways of Producing This Vapor, one being to expose a considerable surface of area of this liquid to the air, which is also caused to bubble through it and thus become impregnated with the gasoline vapor.

The Second Method Is to "Spray" the liquid gasoline through a fine nozzle or jet into a small vaporizing chamber and into which air can be drawn to intermingle with the vapor.

The Device in Which This Operation Is Performed Is Termed a Carburetor, and the operation itself is known as **carburetion,** from the fact that the gasoline largely consists of carbon. The mixture might also be termed "carbureted" air. The best explosive proportions of gas to air range from 1 to 18 to 1 to 20.

GASOLINE.

The Most Usual Fuel for Automobile Engines is gasoline.

Gasoline is distilled from mineral oil (petroleum).

When Petroleum Is Heated, it gives off gases just as water, when heated, gives off steam.

When These Gases Are Cooled, they become liquids, and are called gasoline, kerosene, benzine, naphtha, etc.

The Chief Difference Between Them is their VOLATILITY.

When a Liquid Turns to Vapor, or gas it is said to be VOLATILE.

Temperature makes a great difference in the volitility of liquids; for instance, thick, heavy oil is not volatile at the ordinary temperature of the atmosphere, but is volatile when heated.

Gasoline Is Very Volatile at the ordinary temperature of the atmosphere.

It is so volatile that it must be kept in air-tight tanks, for it would entirely evaporate if left exposed to the air.

Because of This Volatility, gasoline must be handled with care to prevent fires and explosions.

It Should Never Be Handled Near an Open Flame; a lamp or candle, a fire in a stove, a lighted match, will set it in a blaze.

In Filling the Tank of the car at night, a pocket electric light should be used; NOT ONE OF THE LAMPS FROM THE CAR.

When Handled With Common Sense, there is no danger.

If the Gasoline Should Catch Fire, do not try to put it out with water for as the gasoline will float on water, it will only spread the flames.

Damp Sand, flour or a wet blanket will smother the fire.

CARBURETION.

Pure Gasoline Vapor will not burn; it must be mixed with air before it can be used in an engine.

To Burn With the Greatest Rapidity and Heat, the air must be in correct proportion to the vapor.

The Exact Amount of Air to be mixed with a certain amount of vapor depends on the quality of the gasoline, and other conditions.

The Carburetor, by which the proportions of the mixture are maintained, is so made that a current of air passes through it when the piston makes a suction stroke. See Chart 52—"Air Intake."

The Air Goes Through a Passage, in which is a small pipe that sprays the gasoline, so that it is in contact with the air. See "Spray Nozzle."

The Gasoline Being Volatile, it is picked up by the air, and the mixture goes to the cylinder.

The Amount of the Air that may flow through the carburetor, and the quantity of gasoline that may flow out of the small pipe, are adjustable, so that for a certain amount of gasoline the proper proportion of air may be admitted.

When the Mixture Is Not Correct; that is, when there is too much or too little air for the gasoline flowing out of the small pipe, the running of the engine is affected, and it will not deliver its full power.

When There Is Too Much Air for the gasoline, the mixture is said to be too POOR; when there is too little air, the mixture is said to be too RICH.

CARBURETORS.

The Carburetor is connected to the inlet valve chamber by the inlet pipe, and no air or gas can enter the cylinder through the inlet valve without first passing through the carburetor.

The Air Sucked Through the Carburetor on the suction stroke enters it through the AIR INLET, and passes through the spray nozzle, the level of the gasoline in the float chamber drops, and the float drops also and permits more gasoline to enter the float chamber

It Is in The Mixing Chamber that the air is brought into contact with the gasoline.

The Spray Nozzle, projects into the mixing chamber, so that it is in the center of the current of air.

When the Air Is Not Passing through the mixing chamber, the liquid gasoline stands just below the open end of the spray nozzle, but as soon as the current of air passes through, it sucks the gasoline out.

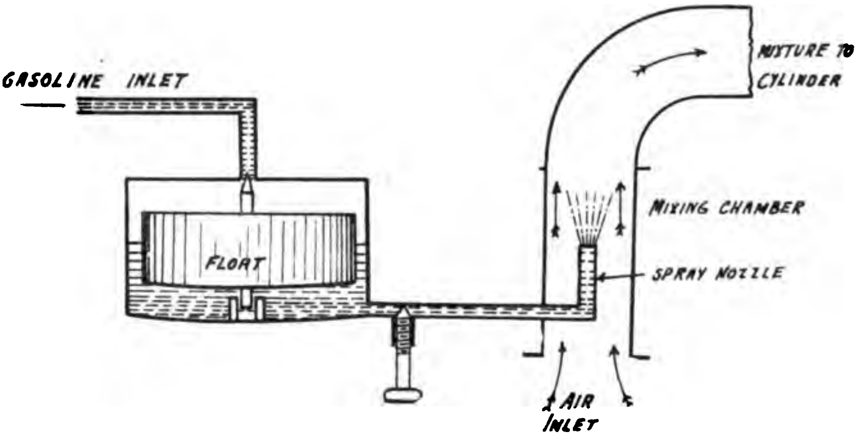


Fig. 1 –The Principle of a Simple Float Feed Carburetor. Note that the gasoline flows from tank through the "Gasoline Inlet Pipe" to chamber of Carburetor in which there is a float.

The Purpose of the Float is to Cut the Flow of Gasoline Off when the chamber is full, otherwise the Gasoline would overflow at the "Spray Nozzle."

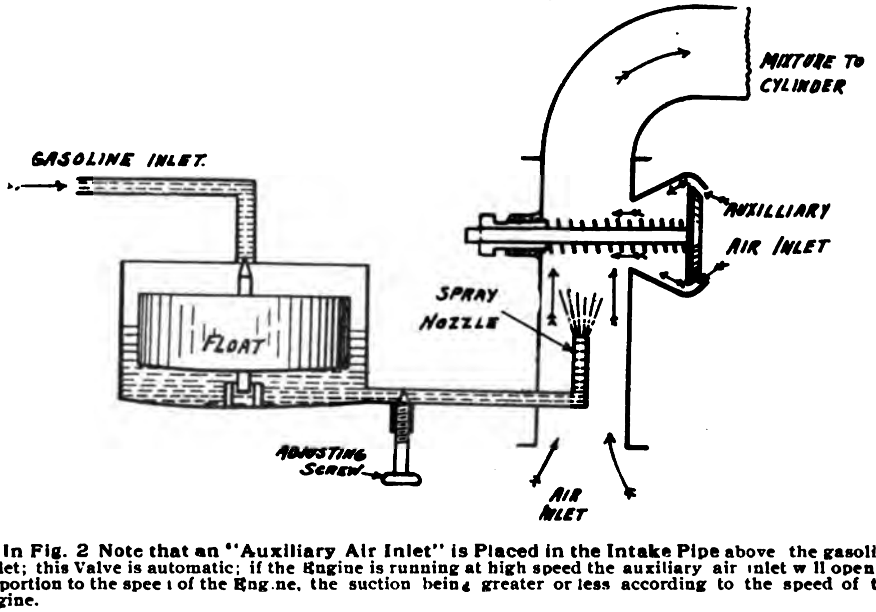
When the Float is Properly Set (usually determined by its weight), the gasoline will not overflow at the nozzle.

When the Engine is Running the suction of the piston draws the gasoline through the mixing chamber from the spray nozzle, through the Intake pipe from Carburetor, through the Intake valve on Engine (see Fig 5 on the Engine working model).

As the Gasoline is Consumed in the Engine the level of the gasoline in the Float chamber (see Fig. 4 of Carburetor model This Float mechanism is different from one shown in this illustration, but the principle is the same), drops and thereby causes the Float to drop and more gasoline enters the chamber.

There are different methods used on various makes of Carburetors for operating the float and cutting off the gasoline, but the principle of practically all Carburetors is about the same.

In Fig. 1—The Main Air Supply is Drawn in at the Bottom of the "Mining Chamber" but inasmuch as the best power of an Engine is obtained by getting exact proportions of air and gasoline usually 18 parts air to 1 of gasoline), the reader will note that if the speed of the Engine varies the air proportion will be too great or not enough.



In Fig. 2 Note that an "Auxiliary Air Inlet" is Placed in the Intake Pipe above the gasoline outlet; this Valve is automatic; if the Engine is running at high speed the auxiliary air inlet will open in proportion to the speed of the Engine, the suction being greater or less according to the speed of the Engine.

Carburetors are Made of brass or aluminum. The Floats are made of cork varnished, or hollow copper or brass balls.

Another feature of carburetion is to break the gasoline up into as many fine particles as possible so that the air will more readily mix with the gasoline and form a vapor. There are different methods of doing this which will be shown further on.

There are many different methods of arrangement of the Float and Air Valves but the fundamental principle remains the same.

CHART No. 53.

The Current of Air Sucks Up the Gasoline, exactly as a man taking a deep breath sucks in an insect flying in front of his mouth.

While There Are Many Kinds of Carburetors, practically all that are used for automobile engines are of the FLOAT FEED TYPE.

A SIMPLE FORM OF CARBURETOR FOR ENGINES WITH STEADY SPEED.

A Diagram Showing the Principle of a simple float feed carburetor is shown on Chart 53, Fig. 1.

The Liquid Gasoline enters the float chamber from the supply tank by the FLOAT VALVE.

In the Float Chamber is a FLOAT, either made of cork, well varnished to keep out moisture, or in the form of an air-tight metal box, which, as it floats on the gasoline, opens or closes the valve.

As the Gasoline Enters, the float rises, closing the valve and shutting off the gasoline when it has reached a certain depth.

The Gasoline Runs Out of the float chamber by the spray nozzle, the float keeping the gasoline at the same level in both.

When the Air Current Draws the Gasoline Out of the spray nozzle, the level of the gasoline in the float chamber drops, and as the float sinks, the valve is opened and more gasoline admitted.

The Spray Nozzle is made with a small opening, so that the gasoline comes out in the form of spray, instead of as a stream, which makes it vaporize quickly.

In Some Carburetors, as the gasoline comes out of the spray nozzle it strikes against the end of a small rod, which breaks it into finer spray, and as the object is to make it vaporize as quickly as possible, this is an improvement.

In the Simple Float Feed Carburetor shown, it is only possible to adjust the amount of gasoline flowing to the spray nozzle.

FORM OF CARBURETOR FOR VARIABLE SPEED ENGINES.

This Simple Form is satisfactory for an engine that runs at a STEADY, constant speed, for then the speed of the air current through it does not change, and the gasoline may be adjusted to correspond.

The Engine of an Automobile, however, does not run at a steady speed; sometimes it is running fast and sometimes slow.

The Speed of the Air Current passing through the carburetor depends on the speed of the engine; when the engine is running fast the speed of the air current through the carburetor is much greater than when the engine is running slow.

The Greater the Speed of the Air Current, the more gasoline it will suck out of the spray nozzle, and the adjustment of the gasoline flow that will give a correct mixture at a low speed will give a rich mixture when the air current moves at a higher speed.

Carburetors for Engines That Run at Changing Speeds are therefore made so that an extra supply of air is admitted when the air current flows so fast that it results in too rich a mixture.

This Type Is Called a Compensating Carburetor, and is used on practically all automobiles.

The Action Depends on the greater or less suction that faster or slower speeds of the engine give.

In a Simple Form, the extra supply of air, which reduces the rich mixture formed in the mixing chamber, is admitted through a valve placed above the spray nozzle, which is controlled by an adjustable spring.

The Suction Produced from the suction stroke of the piston draws the valve open, just as an automatic inlet valve is drawn open.

A Compensating Float Feed Carburetor is shown on Chart 53, Fig 2.

The Float Feed and the Spray Nozzle are the same as in the simple float feed carburetor, the difference being in the AUXILIARY AIR INLET.

As the Rush of Air Through the Mixing Chamber becomes greater and greater because of the increased speed of the engine, the air valve is drawn open correspondingly wider, the spring being adjusted so that the proper amount of fresh air is admitted to bring the rich mixture to the proper proportions.

The Arrangement shown in the two diagrams described, with the float chamber on one side of the mixing chamber, may give results that are not satisfactory, for if the car tilts, the level of the gasoline in the spray nozzle and float chamber changes.

If the Carburetor Is Tilted, the gasoline will either stand some distance below the tip of the spray nozzle, requiring more suction to draw it out, resulting in poor mixture, or

The Gasoline Will Run Out because the tip of the spray nozzle is below the level in the float chamber, resulting in a rich mixture.

To Overcome This Difficulty, many carburetors are made with the mixing chamber inside of the float chamber, as shown in Chart No. 54, Fig. 1.

In This Case, the float is ring shaped, and surrounds the mixing chamber, which passes through the float chamber.

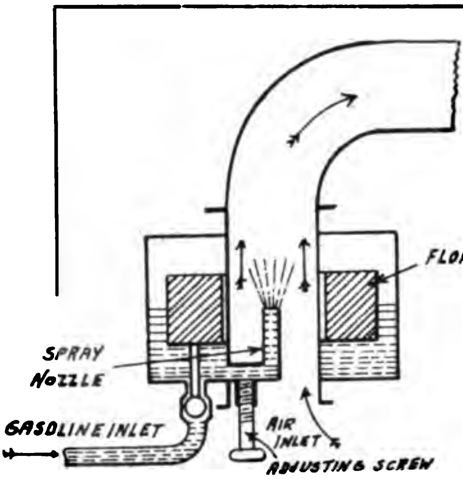
This Form Is Very Compact, and there are two or three connections between the float chamber and the spray nozzle, the gasoline will not overflow with ordinary tilting.

The Size of the Opening of the spray nozzle makes a difference in the action of the carburetor, and the larger the opening, the more gasoline will be sucked out.

The Adjusting Screw frequently is applied directly to the spray nozzle opening, being in the form of a slender needle valve, so that the size of the opening is changed.

It Is An Advantage to have this arrangement, for the point of the valve keeps the opening clean.

A Little Dirt, or a thread of cotton waste, may easily stick in the opening, preventing the gasoline from flowing out, cutting it down so that it gives a poor mixture.



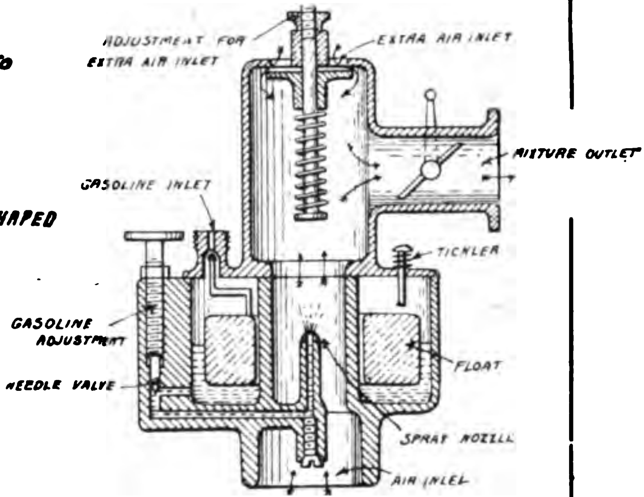


Fig. 1—Carburetor with the float around the mixing chamber, called the concentric type of float. Air supply is drawn in at bottom of mixing chamber below the spray nozzle. This illustration shows only this main air supply.

Fig. 2—Carburetor with the float around the mixing chamber (concentric type). Air supply is at the bottom, below the mixing chamber and is called the "main air supply."

An automatic auxiliary air supply is shown at the top of the carburetor. This auxiliary air valve is called automatic, because the air is automatically controlled by the spring tension against the valve. If the Engine is running fast the valve will open wider and admit more air, caused by a greater suction. The throttle valve (Butter-fly type), is shown in the outlet tube. This outlet tube connects with the intake pipe of the Engine. The opening and closing of this throttle admits more or less gas to the Engine and is controlled by hand lever on the steering wheel.

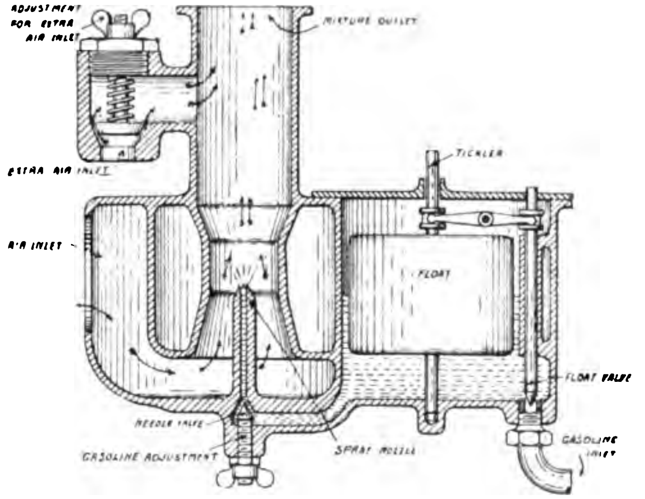


Fig. 3—This type of Carburetor has a side float chamber. Note the mechanism attached to the float to cut off the gasoline. The main air inlet is at the side but permits the air to enter below the spray nozzle.

The automatic auxiliary air supply is taken in at the top (over the spray nozzle), just the same as the one in Fig 2, but the arrangement is different only.

CHART No. 54.

The Float Valve is also liable to be stopped up, or a little dirt may prevent the valve from closing, so that the gasoline FLOODS the float chamber.

This Gives a Rich Mixture.

There Is Usually a Strainer in the feed pipe, consisting of thickness of brass wire gauze through which the gasoline flows.

This Strainer is often built into the carburetor, and may be withdrawn for cleaning by unscrewing a plug.

As the Carburetor is always placed at the lowest point of the feed pipe, impurities will settle in it, and in the best form there is a plug that may be unscrewed to permit the parts to be easily cleaned.

Fine Steel Wires, with rounded ends, should be carried in the kit, for cleaning the fine passages.

The Temperature of the air makes a difference in the operation of a carburetor, for warm air will vaporize the gasoline more quickly than cold.

In Order to Have the Temperature Even, the air inlet to the carburetor is frequently close to the cylinder or exhaust pipe, which are warm from the explosions.

In This Way, only warm air is drawn into the carburetor, which makes the gasoline vaporize quickly and evenly, no matter what season of the year it may be.

VARIOUS TYPES OF CARBURETORS.

As Compensating or Automatic Carburetors Are Practically in Universal Use for gasoline automobile engines, the general construction of the leading types of that class are explained; the designs of the various manufacturers are different only in detail, as in the main they follow closely the constructions herein described.

CONCENTRIC FLOAT CHAMBER TYPE.

The Carburetor With the Mixing Chamber passing through the float chamber is called a "concentric float" type because the float surrounds both the spray nozzle and mixing chamber. This makes a compact carburetor and maintains a constant gasoline level in the spray nozzle regardless of the angle at which the car may be.

A Typical Form is shown on Chart No. 54, Figs. 1 and 2.

The Valve Closing the gasoline inlet is attached to the float, which on almost all ring float carburetors is of cork.

The Needle Valve Controls the Flow of the gasoline to the spray nozzle, and the correct adjustment of it is necessary for the operation of the carburetor.

In Many Carburetors this adjusting screw passes through the spray nozzle lengthways, so that when it is closed it fills the spray nozzle opening so that no gasoline can pass.

In Such a Position it also helps to break the gasoline into spray.

The Greatest Difference in carburetors of this type is in the position and action of the extra air inlet.

In the One Shown, there are openings in the top, closed by a valve pressed against them by a coil spring. Fig. 2.

The Weaker the Spring, the less suction it will take to draw the valve open, and it may be adjusted by a lock nut that secures it in position.

PRIMING THE CARBURETOR.

There Is on All Float Feed Carburetors an arrangement for PRIMING or "TICKLING", which means to depress the float by hand so that the float valve will open and admit gasoline to the float chamber.

This Is Usually Necessary when starting the engine, as it insures the presence of gasoline in the carburetor.

Too Much Priming, however, will fill the float chamber so full that gasoline will run out of the spray nozzle, giving a rich mixture, on which the engine will not start.

Recent Improvements in Carburetors to make a motor "easy starting" consists of a mechanism which practically close the main air inlet of the carburetor, and tightly close the auxilliary air valve. This is more modern than the old style "tickler"and has almost become a necessity owing to the quality of gasoline now on the market.

THE THROTTLE VALVE.

The Throttle is placed in the mixture outlet. and the form that is shown is called a BUTTERFLY VALVE. (See Charts 56 and 57.)

It Is a Disc of Metal turning on pivots, so that it acts like the damper of a stove pipe.

When Wide Open, the butterfly valve is edgeways to the flow of the mixture, but even in this position it presents resistence to the flow, which is a thing that should be avoided.

The Sliding Throttle Valve is entirely out of the outlet when open, so that it presents no resistance whatever. (See sliding throttle Chart 55.)

In Some Makes of Carburetors, the extra air inlet is arranged so that it enlarges the regular air inlet, and while this works fairly well, it is not as good as if placed so that the extra air is admitted above the spray nozzle, as shown in Figs. 2 and 3, Chart 54.

In This Position it dilutes the rich mixture, which makes its action better than if it only adds to the volume of air that forms the mixture.

When A Liquid Evaporates, it produces cold, and under some conditions of weather the evaporation of the gasoline in the mixing chamber will freeze it up, the gasoline forming snow and stopping the passages.

This Is More Likely to Happen with a ring shaped float carburetor, because the float chamber protects the mixing chamber from the heat of the engine, while with a side float carburetor the mixing chamber is exposed to the warmth of the engine.

By Providing a Warm Air Intake, however, this freezing may be prevented.

SIDE FLOAT CHAMBER TYPE.

The Float In This Type of Carburetor is usually a tight box made of thin brass, the joints being made so that there is little danger of leakage.

In Order to Offset the Danger of changing the level of the gasoline by tilting, the float and mixing chambers are as close together as possible.

On the Float Arm is a small collar, as shown in Chart No. 54 Fig 3, in which rests the arm of a rocker, the rocker being pivoted in the center.

The Other Arm of the Rocker rests in a similar collar on the stem of the float valve.

As the Float Rises, it carries with it its rocker arm, the rocker turning on its pivot.

This Depresses the other arm of the rocker, which closes the float valve and stops the flow of the gasoline into the float chamber.

This Is a Very Usual Arrangement of the float valve, as it permits the valve to move downward as the float is moving upward in floating on the gasoline.

The Float Rod Forms the Primer, or Tickler, because depressing it lifts the valve and admits gasoline.

The Part of the Mixing Chamber surrounding the tip of the spray nozzle is usually made so that it is smaller than the rest, making the air pass the tip at a higher speed, and closer to the spraying gasoline.

The Mixing Chamber is sometimes surrounded by water jackets, through which circulates a portion of the water from the jackets of the engine.

The Water Being Warmed by the engine, warms the mixing chamber, keeping it at an even temperature, and preventing it from freezing.

In Some Forms, the valve stem passes through the float, and is separate from it, the inlet valve being at its lower end.

A Pivoted Arm, or sometimes two or more, are so set that the end rests in a collar on the valve stem, and the other end, which is heavier, rests on the top of the float.

As the Float Rises, it lifts the arm resting on it, which depresses the other end of the valve stem, closing the valve.

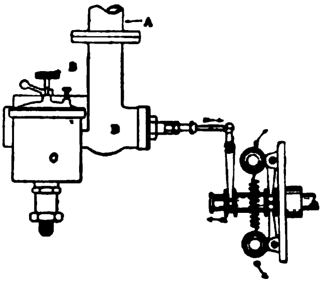


Fig. 1—Centrifugal Type of Governor.

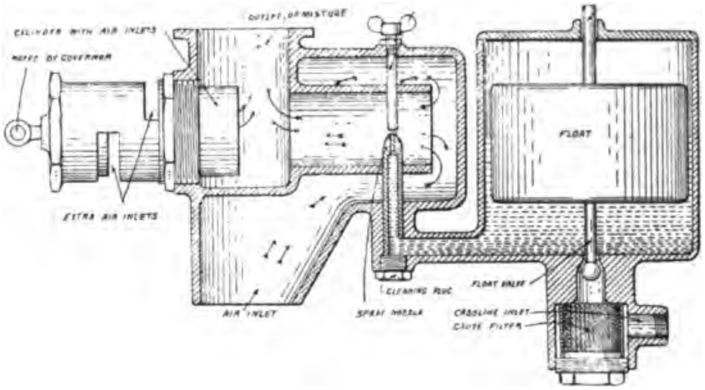


Fig. 2—Sectional View of a side float type of carburetor with a throttle of the sliding type for governor operation.

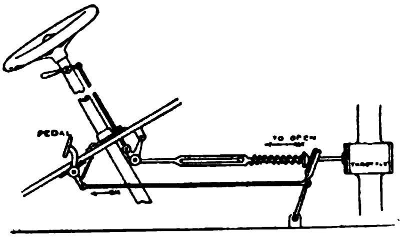


Fig. 3—The Accelerator.

The purpose of the accelerator is to open and close the throttle independent of the governor by means of a foot pedal. See explanation on page 13.

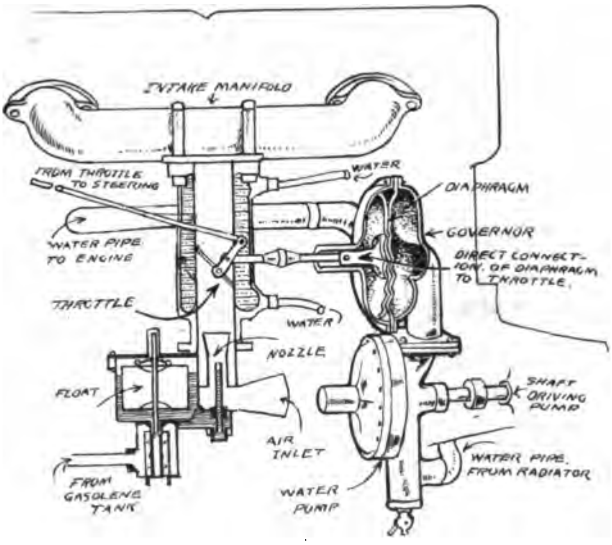


Fig. 4—The Packard Water Governor controlling the carburetor. See page 12 for explanation.

Governor Types of Carburetor.

CHART No. 55.

When the Float Falls, the weighted end of the arm falls with it, lifting the other end of the valve stem, opening the valve.

The Gasoline Adjustment is similar to that of the ring float carburetors, as is also the extra air inlet.

GOVERNOR TYPE OF CARBURETORS.

Only a Few Makes of Cars are Still Using the Governor, although at one time it was popular, but the rapid development of the carburetor now obviates the necessity of using this complicated mechanism.

Stationary Gasoline Engines use governors to a great extent.

A Brief Explanation of a Governor is as follows:

The Principle on Which a Governor Acts is that of centrifugal force, which is an adaption of the old system of governing steam engines.

Connected to the Engine Shaft is a device consisting of a pair of pivoted arms, having weights at one end and connected by a spring which controls them. (See Fig. 1, Chart. 55.) These weighted arms when at rest come close together, but when in motion they extend or fly outwards to a degree depending on the speed.

A Sliding Collar connected to the pivoted arms is pushed outwards as the speed increases, causing a lever to operate the throttle valve.

This Will Be Understood by referring to the illustration.

As the Speed of the Engine Tends to Increase, the action of the governor reduces the gas supply by closing the slide throttle (See Fig. 2) to a certain extent.

If the Load on the Engine Is Such that it tends to lower the speed, the throttle opens wider and admits more gas.

THE PACKARD GOVERNOR.

The Packard Automobile Engine is fitted with a Governor which controls the throttle on the Carburetor by the pressure of water circulation. (See Fig. 4, Chart 55.)

A Hydraulic Governor of the Diaphragm Type is located directly above the water pump.

It Is Operated by the Pressure of the Water in the water circulation system.

It Consists of a circular chamber divided by a flexible diaphragm of leather and rubber.

On One Side of the Diaphragm is a water space through which passes the water of the circulating system.

On the Other Side is an air space and a plunger head against which the diaphragm presses. The plunger is directly connected with the throttle valve.

If a Decrease in the Load on the Motor Causes its Speed to Increase, the pressure of the water, circulated by the pump, increases and, consequently, the diaphragm exerts more pressure toward the rear, tending to move the plunger and thereby close the throttle.

As the Motor Speed Decreases, the water pressure against the diaphragm is lessened and the throttle may open.

If the Load on the Motor Increases, the opposite action of the governor will result.

PACKARD GOVERNOR EFFECT.

The Governor Prevents the Motor from Racing when the load is removed, as by throwing out the clutch or stopping the car without stopping or shutting down the motor.

The Governor Also Tends to Maintain a Constant Speed of the car within the limits of the hand throttle setting, when road conditions vary.

The Action of the Governor is an indicator of low water in the radiator.

When the Engine Is Stopping, the governor tends to open the throttle and thus assist in charging the cylinders so that the motor will start easily.

THE ACCELERATOR.

It Is Sometimes Desirable to Allow the Engine to Accelerate Above Its Normal Speed, and for this purpose a device is fitted which prevents the governor acting for the time being.

This Device Is Termed an Accelerator.

This Would, of Course, Only Be Used in Circumstances when the utmost power was required from the engine, as when a very steep ascent has to be surmounted. For operating the accelerator a small pedal is provided.

A Combination of Hand Throttle and Foot Accelerator is generally fitted on cars, most of the driving being done on an accelerator pedal.

Where No Governor Is Fitted the accelerator takes the form of a special throttle, which can be set by hand to allow enough gas to pass into the engine to keep it running on light load.

For Speeding Up the Engine the pedal is kept depressed.

HOW THE SPEED OF AN ENGINE IS CONTROLLED.

The Simplest and Probably the Acknowledged Popular Method for Controlling the Speed of an automobile engine is by opening and closing the throttle valve on the carburetor by hand.

A Rod Leading From the Throttle Leaver on the throttle valve connects with a hand lever on the steering wheel. (See Fig. 4, Chart 56) The driver then has the power under his control at all times.

If Running on a Level and More Speed Is Desired, the throttle lever is "advanced" and the throttle is opened until the required speed is maintained. By Closing the throttle the speed is decreased.

The Throttle Valve is never entirely closed.

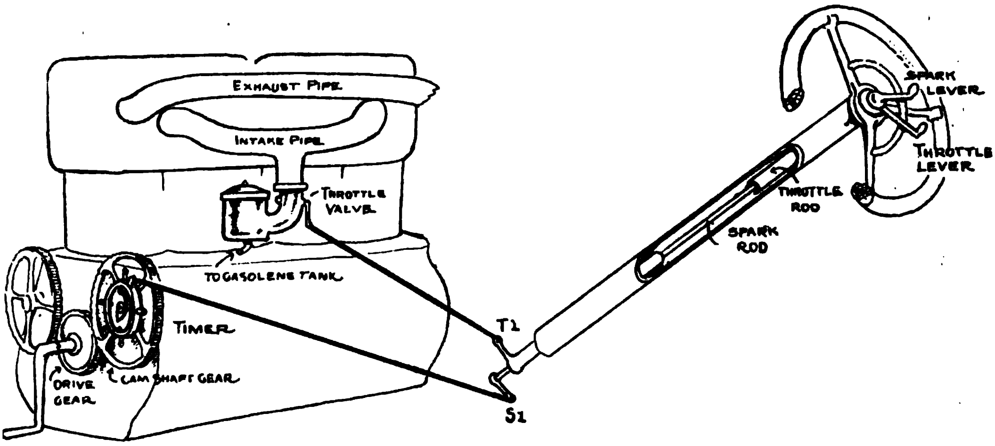


Fig. 4.

Fig. 4. Illustrating the connection between the carburetor throttle valve on the carburetor and the throttle lever on the steering wheel. The purpose of this drawing is to explain how the speed of an engine is controlled by hand (no governor).

The spark must be "advanced" as the throttle is opened. This is done by shifting the timer, and causing the spark at the points of the spark plugs in the cylinder to spark and ignite the gas earlier.

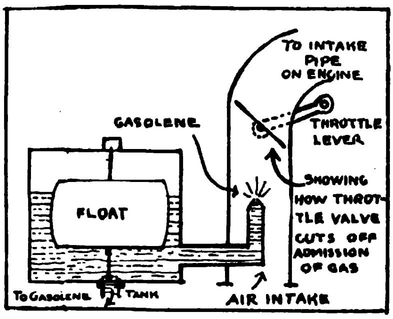


Fig. 5.

Fig. 5. This illustration shows how the throttle (butterfly valve) closes up the mixing chamber. In other words, the purpose of this drawing is to explain how the throttle controls the admission of gas into the cylinder.

The Butterfly Valve type of throttle is the style in general use.

It Is Natural to Assume that if more gas is admitted to the cylinder, more speed and power will be developed. If the gas is cut off at the throttle valve, the explosion force will be less; consequently less speed and less power.

The Reader Will Also Observe that the inlet valve must open at the proper time; for instance, suppose the piston was half way down on its suction stroke, (See Chart 52) before the nose of the cam opened the valve to admit the gas—in this instance the cylinder would be filled with only half a charge and the engine would not develop its power. The proper setting of the inlet valve to admit a full charge and the proper setting of the exhaust valve to discharge the burnt and useless gas is very important.

As the Throttle Is Opened and the speed of the engine is increased it is also necessary to cause the spark to occur at the points of the spark plug earlier in order to keep up with the increased speed.

The Spark Lever Is Advanced by shifting it forward on the steering wheel.

When the Spark Lever Is Shifted Forward on the steering wheel the timer will be shifted to a position that will cause the contact to be made earlier and thereby cause the spark to occur earlier—(This subject will be treated further on under the subject of Ignition.)

To Stop the Engine the spark is cut off and the ignition is stopped.

The Working Model of the Engine, the illustration in Chart 52 ought to make the subject clear.

CARBURETOR CONSTRUCTION.

There Are Various Types of Carburetors, in fact a score or more, although the construction varies, the principle remains about the same.

Classified According to Structure and Operation, we will mention the construction of the parts now in general use.

PARTS OF THE CARBURETOR.

THEIR VARIED CONSTRUCTION—THE FLOAT.

Floats Are Usually Made of light brass or copper in various hollow forms; the joints, if any, being carefully soldered or brazed so that gasoline cannot enter the float itself.

Floats Are Also Made of Cork, well varnished so that they will not absorb gasoline and become heavy.

Gasoline Leaking Into the Float increases its weight, thereby changing the proper gasoline level in the spray nozzle and causes the carburetor to flood.

There Are Many Types of Floats and Float Mechanisms as will be seen in the illustration in various carburetors in this instruction.

PURPOSE OF THE FLOAT.

The Sole Duty of the Float is to maintain a predetermined level of the gasoline in the carburetor.

This Level Is Generally a small fraction of an inch below the jet opening or nozzle.

As Gasoline Flows From the Main Supply Tank through the gasoline pipe or line into the float chamber of the carbuetor, the float rises

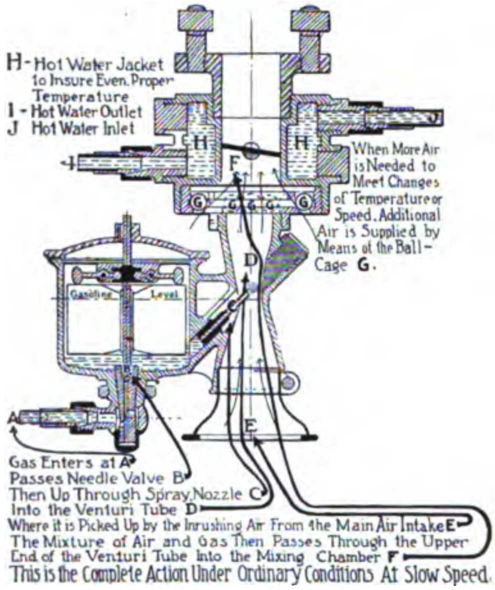

H - Hot Water Jacket to Insure Even, Proper Temperature
I - Hot Water Outlet
J Hot Water Inlet
H
H
F
G
G
G
G
G
D
C
E
A
I
J
Gasoline Level
When More Air is Needed to Meet Changes of Temperature or Speed, Additional Air is Supplied by Means of the Ball-Cage G.
Gas Enters at A
Passes Needle Valve B
Then Up Through Spray Nozzle C
Into the Venturi Tube D
Where it is Picked Up by the Inrushing Air From the Main Air Intake E
The Mixture of Air and Gas Then Passes Through the Upper End of the Venturi Tube Into the Mixing Chamber F
This is the Complete Action Under Ordinary Conditions At Slow Speed.

Fig. 1—The G. & A. Carburetor with a side float—gasoline entering at bottom. This float is similar to the float on the carburetor working model. The air intake of this carburetor is controlled by balls instead of springs. The jet is a single "spray" jet.

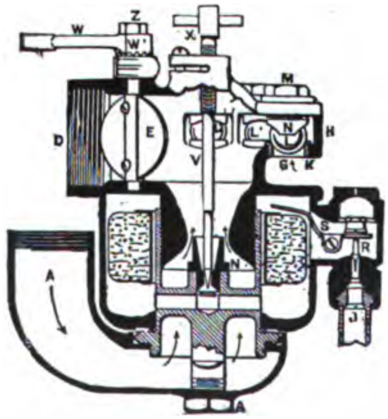


Fig. 4—The Kingston carburetor concentric type of float. In this type the gasoline valve R is closed by the upward movement of the concentric float. The adjustable needle V determines the size of the spray jet opening.

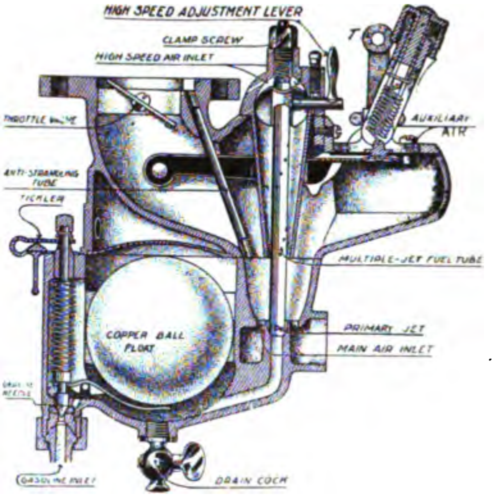


Fig. 2—The Carter (Model A) side float chamber. Seamless copper float. True type "multiple" jets. Auxiliary air valve spring subject to control from the car dash. This type is particularly adapted to six cylinder motors.

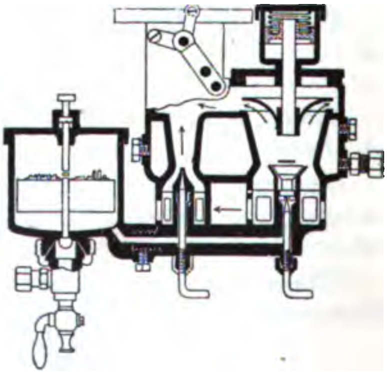


Fig. 3—A Carburetor side float with a "double jet" spray nozzle.

CHART No. 57.

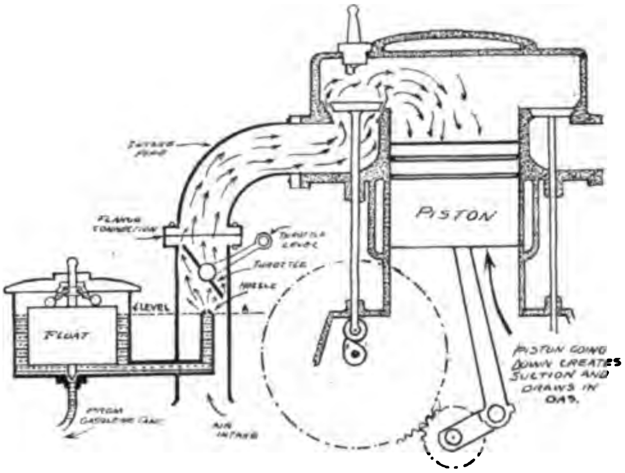


Fig. 1. Explaining how the gasoline and air is drawn into the cylinder by suction of the piston from the spray jet, pass the throttle, through the intake pipe, thence through the intake valve, by the suction of the piston.

As the gasoline is drawn out of the spray nozzle, the level of the gasoline drops and the gasoline needle valve opens and admits more gasoline (see carburetor model; this float works on the principle shown in the model).

The gasoline, in this manner, is kept at a constant level.

If the engine stops, the float cuts off the gasoline supply and thereby keeps the float chamber from flooding.

Before the float was invented and added to the mixing chamber, the gasoline run to the mixing chamber direct and when the motor stopped the driver had to cut off the gasoline by hand. This old-style mixing chamber was called a "mixing valve."

The gasoline level in the float chamber must be kept at a level so that the gasoline will not overflow at the spray nozzle; otherwise the gasoline would overflow at all times, even when the engine was not running.

The level in the float chamber must be so that the gasoline will be maintained just below the level of the top of the spray nozzle. The suction will draw it out.

This exact distance of level below the top of the jet varies in different makes of carburetors.

This level can be adjusted by making the float heavier or lighter, or by float adjustments provided on some makes of carburetors.

CHART No. 58.

and the gasoline needle valve shuts off the further entrance of the fluid into the carburetor.

When the Motor Is Running and Using Gasoline the float in the carburetor is continually falling and rising slightly, always maintaining the approximate gasoline level in the float chamber.

The Gasoline Needle Valve on some carburetors closes by means of a positive spring action which operates when the float reaches a certain level. In others the needle itself is of sufficient weight to close the gasoline opening at the proper time by gravity alone.

Still Others by means of a lever, use the buoyancy of the float to force the gasoline needle closed.

The Float Mechanism Shown in Illustration, Fig. 1, Chart 57, is a foreign type of mechanism used quite extensively and is best explained with the working model of the carburetor. There are many different methods or types of mechanism to operate the gasoline needle valve, but the principle is about the same in all.

FLOAT CHAMBERS.

Float Chambers are sometimes placed to the side of the mixing chamber and sometimes around the mixing chamber as previously explained.

FLOAT LEVEL.

In Different Makes of Carburetors the level of the gasoline in the float chamber and the gasoline in the spray nozzle varies from about one-sixteenth to one-eighth of an inch below the top of the spray nozzle.

SPRAY NOZZLE.

The Spray Nozzle in This Carburetor, the fuel is discharged into the mixing chamber through the spray nozzle.

As Its Name Implies, is intended to deliver the liquid in the form of a fine spray, which is: 1, vaporized more or less; 2, mixed with the entering air, and 3, carried by the suction into the engine cylinder.

The Simplest Form of Spray Nozzle is one having a single opening, as shown in Fig. 1, Chart. 58.

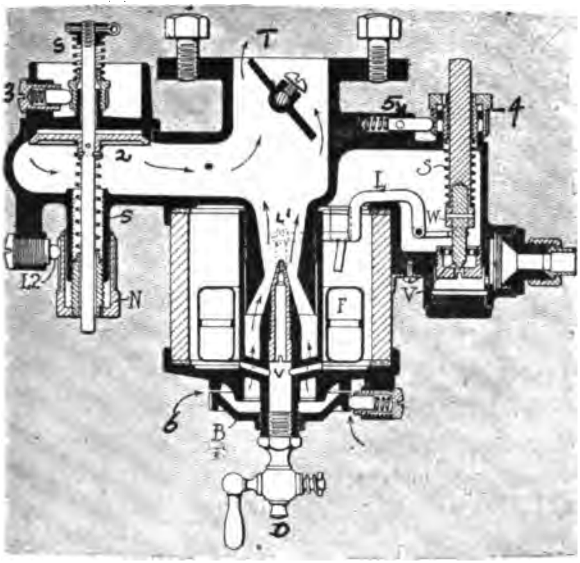
Some Carburetters Have Two Spray Nozzles or Jet Tubes as shown in Fig. 3, Chart 57.

Another Type Has What Is Called a "Multiple Jet" spray nozzle, as shown in Fig. 2, Chart 57.

When a Carburetor Has More Than One Jet it is particularly adapted to a multiple of cylinders of large size and especially six-cylinder engines.

THE MIXING CHAMBER.

This Consists of an Enclosure or passageway containing the nozzle. The gasoline and air is mixed within this tube in proper proportions and then drawn through the throttle into the engine.



The Stromberg, a Venturi type of carburetor. This carburetor has a Venturi type of tube and a concentric float. Adjustable air intake and spring adjustment for the auxiliary valve.

The float F controls supply of gasoline through lever L which is pivoted at L1 and is connected to needle valve W. This pin is adjustable by nut 4 which is held in position by fig 5. Drop cock D drains the chamber. The nozzle tube receives its supplementary supply of air from opening 6 then it passes through throttle T from auxiliary valve 2. This auxiliary valve is controlled by spring S. The springs are adjustable at N and are locked at 12.

Fig. 1—The Stromberg Carburetor.

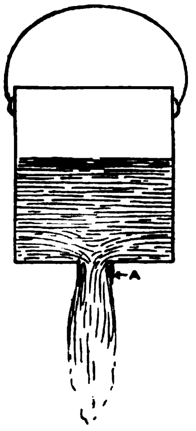


Fig. 2.

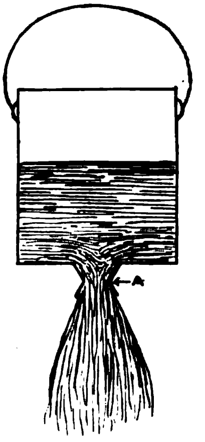


Fig. 3.

Explanation of VENTURI.

If two buckets were placed side by side both filled with water, and for example, a one inch opening cut in the bottom of each. One to have a plain opening as in Fig. 2-A, and the other to have a "Venturi" opening as in Fig. 3-A, the same volume of water would flow out of the Venturi one inch opening much quicker than through the plain one inch opening in Fig. 2-A.

Note the shape of the Venturi opening, A Fig. 3—then note a similar shaped tube in the mixing chamber in Fig. 1.

CHART No. 59.

MAIN AIR INTAKE.

All Carburetors of Modern Design Have a Main Air Intake usually placed below the jet at the bottom or side of the carburetor.

AUXILLIARY AIR INTAKE.

An Auxilliary Air Intake is usually placed above the jet. The later being controlled automatically by the suctions of the gas going into the cylinder draws air through the auxilliary air intake, through the valve which operates against a spring tension, for instance see the auxiliary air intake in the carburetor, Fig. 2, Chart 52 and 54.

THE BALL TYPE.

Another Method for Automatically Opening and closing the auxiliary air intake is shown in Figs. 1 and 4, Chart 57 .

Instead of a Valve and a Spring, balls are utilized instead.

VENTURI TUBE.

The Venturi Tube Around the Spray Nozzle is the accepted type and is now made in almost all makes of carburetors.

The Principle and Purpose of the Venturi Tube around the spray nozzle is in order to get a greater volume of air through a predetermined sized opening in quicker time.

Explanation of the Venturi Action is shown in Chart. 59.

CARBURETOR THROTTLE VALVES.

The Type of Throttle Valve used on almost all makes of carburetors is the butterfly valve type.

This Type of Throttle Is Shown to advantage in Fig. 2, Chart 57.

The Mechanism and Method for controlling the throttle is shown in Chart 56.

GOVERNOR THROTTLE.

A Throttle Valve on a carburetor controlled by a governor is made different, it is made in the form of a cylinder and slides easy and is connected to throttle. (See Figs. 1 and 2, Chart 55.)

AN ACCELERATOR

Is Usually a Foot Pedal and works independent of the governor and hand control, is used to suddenly increase the speed by pressing the foot on a pedal which opens the carburetor.

The Dictionary Gives the Meaning of the Word Accelerate as follows: To hasten; to cause to move or progress faster; quicken the speed of.

ADJUSTMENT OF CARBURETORS.

Owing to the fact that innumerable improvements have been made in carburetor construction in the last year or so, it is impossible in this instruction to describe the actual adjustments of all the carburetors now in use. Therefore, would advise that anyone before attempting to adjust a carburetor with which he is not thoroughly familiar, should secure an instruction book or catalogue detailing the adjustments. Repairmen are advised to secure instructions for adjustment of all the leading makes of carburetors.

To Adjust a Carburetor, close the gasoline adjusting screw, and tighten the air valve spring, first loosening their lock nuts.

Open the Gasoline Adjustment a quarter of a turn, and crank the engine, having primed the carburetor. (Meaning:—push the float down.)

Crank the Engine to draw the mixture into the cylinder, and see if it shows signs of igniting.

It must Be Remembered that only a very little gasoline is required in proportion to the air.

If There Is no Sign of Ignition, open the gasoline valve a little more, and crank the engine again.

The Mistake That Is Usually Made by novices is the giving of too much gasoline, and a rich mixture will not run the engine any more than a poor one.

By Opening the Valve a little at a time, and trying the effect of each adjustment, the charge will finally ignite, and the engine will begin to run slowly.

When Once Started, it is easy to make a more careful adjustment.

When the Engine Is Running, open the RELIEF COCK in the cylinder head, which communicates with the combustion space.

At Each Explosion, a jet of flame will shoot out of the relief cock, and this flame is an indication of the condition of the mixture.

If the Mixture Is Too Poor—too much air for the gasoline—the flame will be light yellow.

If the Mixture Is Correct, the flame will be blue, and hardly visible.

If the Mixture Is Too Rich—Not enough air for the gasoline—the flame will be red and smoky.

Black Smoke Will Also Come out of the muffler, smelling of raw gasoline.

A Rich Mixture will leave a deposit of carbon in the cylinder, leading to PREIGNITION and will foul the points of the spark plug, preventing the spark from passing.

During the Adjustment of the Gasoline; the engine has been running slowly, with the spark RETARDED, and to adjust the auxiliary air inlet it must be run at a higher speed.

The Air Valve having been tightened when the adjustment of the carburetor was begun, it will not open and consequently the high speed of the engine, which increases the speed of the air current, will result in a mixture that is too rich.

The Spring of the extra air valve must be lossened a little at a time, noticing the effect that each change has on the engine.

If the Spring Is Too Tight, the valve will not open easily, and the mixture will be too rich—if it is too weak, the valve will open too soon, and the mixture will be too poor.

When Correctly Adjusted, the engine should run at high speed as well as it does on low.

A Good Way to Get the Adjustment Accurate is to have someone run the car at various speeds, changes in the tension of the air valve spring being made while kneeling on the floor or running board.

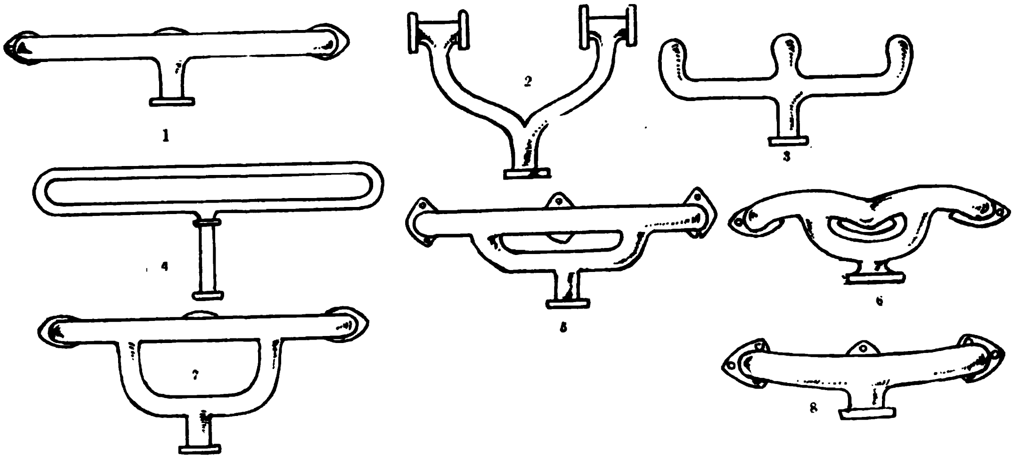


Fig. 1—Various Shapes of Intake Manifolds Used on Different Cars.

Each manufacturer tries to make a manifold which will have the least number of curves, and as straight and as short a path for the gas to travel through as possible. The ideal intake manifold is easily specified. It is one in which equality of distribution is had, both qualitatively and quantitatively, and in which no unnecessary resistance is offered to the flow of the mixture. The intake manifold connects over the intake valve openings on the cylinders. See chart 49A. in Instruction No. 10 showing how an intake manifold is attached to Engine. An intake manifold for a six-cylinder Engine which would deliver an equal mixture to each cylinder has been a problem with manufacturers. If the distance is too great the gas tends to condense and the path must be equal. The above manifolds are designed for six-cylinder Engines. The reader can compare them and fignre out in his own mind the best design.

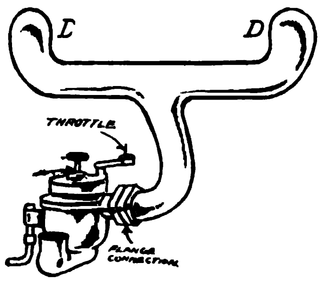


Fig. 2—Carburetor Attached Horizontally.

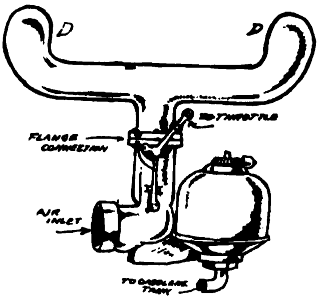


Fig. 3—A Carburetor Attached to the Intake Manifold Vertically.

Illustrating a carburetor attached to the intake manifold.
The carburetor is attached to the manifold by a flange.
The manifold at D is attached to the cylinder.
Quite frequently there is an air leak at D and the flange connection, which weakens the charge being drawn into the cylinder.

A FEW HINTS.

When Adjusted, tighten the lock nuts, that the jolting of the car may not make any changes, and do not alter the adjustment until the change from winter to summer makes it necessary because of the difference in temperature of the air.

The Air Inlet of the carburetor should be covered with wire gauze, that dust may not be drawn in, but great care should be taken to keep the gauze clean.

If the Gauze Is Covered With Dust it will prevent air from entering, and it must be thoroughly cleaned.

This Is Best Done with a tooth brush and gasoline.

It Is Well to Remember that if the gauze is oily it will hold dust that would not stick to a clean surface.

Keep the Gauze, as well as the mouth of the air inlet, free from grease and oil; there will then be less danger of dust and dirt collecting on those parts.

The Inlet Pipe, connecting the carburetor to the inlet valve chamber, should be large, and present no resistance to the flow of the mixture.

Sharp Bends or turns will make it harder for the mixture to pass, and therefore if bends cannot be avoided they should be as easy and flat as possible.

WHAT TO DO IN CASE OF CARBURETOR TROUBLES FIRST SEE IF YOU ARE OUT OF GASOLINE.

The Operator Should First Look into the gasoline tank and see if there is any more liquid left.

He Should Then Observe whether or not the valves that permit the liquid to flow to the carburetor are open.

IS THERE AN AIR LEAK?

If the Carburetor Primes, showing ample evidence of a good supply of gasoline, the next question is, does the manifold leak air at a point between the carburetor and the cylinders at flange or D in Chart 60, Fig. 2?

If So, the Leaks Must Be Stopped; this may be accomplished by tightening up on the holding bolts or renewing the packing if necessary, unless, perchance, there is a blow-hole in the manifold casting, or some other flaw that is at the bottom of the leak.

At All Events, the Manifold Must Be Tight, and to stop up a flaw, is a mere matter of whittling a stick and driving it into the hole so that it will stay there, pending the time when a more artistic repair can be made.

MAY NOT BE THE CARBURETOR AT ALL.

If the Trouble Still Persists, the Ignition system Should be given a Measure of Attention; find out if the battery is in strength to serve for its purpose; examine the wiring for loose joints; inspect the timer and see if the brushes are in good bearing, and so such other things as are more likely to be at the seat of the trouble than the carburetor.

BE SURE IT IS THE CARBURETOR.

But if the Carburetor Must Be Attacked, arrive at a good understanding of its functions and how they are performed before making the adjustments.

Referring to Fig. 2, Chart 53, of a section of a carburetor, which is presented merely to help the understanding, remembering that it is not a regular carburetor of the market, it will be observed that the gasoline flows into the float-bowl from the top in this case (it might come in at the bottom in other examples) and the needle serves as the obstruction, preventing the flow of the gasoline when the quantity of the liquid present in the bowl is sufficient to buoy up the float and lift the needle against its seat.

To Prime the Carburetor it is necessary to press down on the primer, the stem of which bears against the float (see tickler, Fig. 2, Chart 54), overcoming its buoyancy, causing it to sink, thus permitting the needle to back away from its seat and allow additional gasoline to enter so that when the priming operation is completed the gasoline will flow out of the nozzle, due to the raising of the level of the gasoline on account of the difference in the head between the liquid in the float-bowl and the orifice of the nozzle.

IF GASOLINE WILL NOT FLOW.

If the Gasoline Will Not Flow From the Float-bowl to the nozzle, it must be on account of an accumulation of foreign matter in the passageways, in which event it will be necessary to back out the screws and with a piece of wire clean out the passageway, thus permitting the gasoline charged with foreign matter to depart.

MAY BE CLOGGED UP WITH SOME OBSTRUCTION.

The Means at Hand for Cleaning out the passageways of carburetors are not always in the same place, but it will be easy enough to find them in well contrived carburetors, and the point here is to remember that gasoline carries paraffine and sediment on occasions, which adhere to the walls of the passageways and stop off the flow of the liquid.

Tracing Gasoline to the Nozzle as the result of priming, assures that the supply of the liquid will be in sufficient presence if the nozzle is not stopped up.

ONE WAY TO CLEAN A CARBURETOR.

Way to Ascertain As to the Condition of the Nozzle is to open the drain cock in line with the same and shove a piece of wire through the nozzle for the purpose of cleaning it out.

ADJUSTING THE AIR AND GASOLINE.

Having Thus Completed the Exploration for the Purpose of Freeing the Passageways for the Liquid, it will be timely to adjust the relation of the gasoline that flows out of the nozzle to the air that is sucked in by displacement of the piston.

In Adjusting the Relation of Air to Gasoline the first thing to do is to either increase the flow of gasoline by adjusting the needle valve in the nozzle, if the carburetor is of the type that affords one, so that the amount of liquid that will pass into the incoming air will be sufficient to make the motor run (without load) at its lowest possible speed, and the slower that the motor can be made to turn over the better will be the result.

Having Completed the Low Speed Adjustment, the next operation is to speed the motor up until it shows confusion, which will be due to an over-rich mixture on account of the tendency on the part of the gasoline to increase its rate of flow in a greater ratio than the rate of flow of air, and the second adjustment must be for the purpose of diluting the mixture, which may be done by admitting more air through the auxiliary valve.

MIXTURE.

The Mixture should be richer at low speed than at high.

At Low Speeds more heat is lost to the cylinder walls, more compression is lost by leakage, and the combustion can therefore be slower, thus sustaining the pressure.

At High Speeds the compression is higher, due to less leakage and less loss of heat.

A Lean and Highly Compressed Charge Burns Faster and hence gives better pressures and fuel economy than a richer one.

The Quantity of Mixture That an Engine Will Take varies greatly with the speed.

At Slow Speeds the volume at carburetor pressure is equal to the cubic content of the cylinders multiplied by the number of power strokes.

At High Speeds of one thousand revolutions or over the quantity may drop to less than one-half the amount, depending on the design of the valves, inlet piping and passages. This reacts upon the compression, and hence on the mixture desired for best results.

The Design of the Engine Has a Bearing on the Carburetor Design, which explains the well known but seemingly mysterious fact that a carburetor giving good results on one engine sometimes fails to maintain its reputation when applied to one of different design.

The System of Ignition Used also have a marked influence.

RESULT IN USING TOO SMALL A CARBURETOR.

When a Carburetor Is Small for the Engine, it becomes very cold while in operation, as the amount of heat necessary to effect the evaporation of the gasoline is more than is available from the entering air or than could be secured through the metal carburetor by conduction.

The Temperature of the Metal Part of Carburetor becomes so low that water condenses on it, and, in some cases, is in the form of frost.

HEATING THE AIR INTAKE.

These Results Are Produced by the use of a carburetor too small for the engine.

To Meet These Conditions, some makers provide means for heating the air supply.

This May Be Accomplished by arranging the outside end of the air inlet pipe so as to terminate closely to the exhaust manifold or some hot portion of the engine.

More Attention Should Be Paid to Jacketing Carburetors to replenish the heat taken up by the evaporation of the fuel, and, judging from observation of carburetors now in use.

The Fuel Consumption Decreases with an increase of jacket temperature for a given output, but only up to a certain point.

The Most Effective Temperature seems to be about 100 degrees Fahr.

Besides Heating the Air, carburetors are sometimes jacketed as shown in Fig. 1, Chart 57, and the heat supplied to the jacket by two methods.

One Is By Means of Hot Water, taken from the cooling system by the use of a shunt, and the other by the exhaust gases. Heating the carburetor by cooling water gives good results, but the starting is made more difficult especially in winter as the engine must be run long enough to heat the water.

HOW TO DETERMINE SIZE CARBURETORS TO USE.

The Size of the Carburetor should be determined by the area of the valve opening on the engine and not by the cylinder displacement, as the former is a true measure of the engine capacity.

A Carburetor Cannot Deliver More Charge to a Cylinder than the area of the valve opening will allow to pass.

A Large Carburetor with too much passage area cannot cause an engine to deliver more power than it would with one having a passage equal in area to that of the valve opening.

RESULTS OF USING TOO LARGE A CARBURETOR.

Too Large a Carburetor would not only waste fuel, but reduce the power of the engine by furnishing a weak mixture.

If the Carburetor Is Too Small the engine will not develop its rated power, as it could not deliver a full charge at high speed.

It Follows That the Carburetor of Proper Size should have its passage area equal to the valve opening of the engine.

In Multiple Cylinder Engines this area is equal to the valve opening multiplied by the number of suction strokes which take place simultaneously, determined from the sequence of cranks.

TWO TYPES OF CARTER CARBURETORS.

These herein shown represent in many ways a substantial advance in the art of carburetion Although the designer and inventor is the same in each case the carburetors will be discussed and explained separately as they cover different fields.

MODEL C (Fig. 1.)

A true multiple jet type especially adapted to six cylinder motors of any size and to large four cylinder motors. The gasoline enters gasoline inlet through a small copper gauze strainer into float chamber. The proper level of the fluid is maintained by the Seamless Copper Ball Float. This float being heavy, but buoyant, regulates the admission of gasoline in a positive manner. When the motor is started the suction created in the carburetor draws gasoline out of the Primary or Lowest Jet and mixes it thoroughly with the inrushing air coming through the Main Air Inlet. This is drawn past the throttle into the motor and is sufficient to supply same up to speeds of 15 to 18 miles per hour. The Anti-Strangling Tube shown is very ingenious as the powerful suction through it on low speeds keeps the interior of the carburetor absolutely dry. This does away with the momentary choking or strangling in the motor when the throttle is quickly opened.

As the throttle is opened further sufficient suction or "vacuum" is created around the upper part of the Multiple Jet Tube to cause gasoline to spray through one after another of the upper jets. This is mixed with inrushing air drawn down around said tube. The number of jets engaged in spraying varies instantly as the throttle is opened or closed. The amount of the gasoline can, therefore, by a simple adjustment be easily regulated to automatically furnish the proper mixture in accordance with the variable demands of the motor. The Auxiliary Air Valve is also subject to adjustment, and can be easily set properly for intermediate ranges of speed.

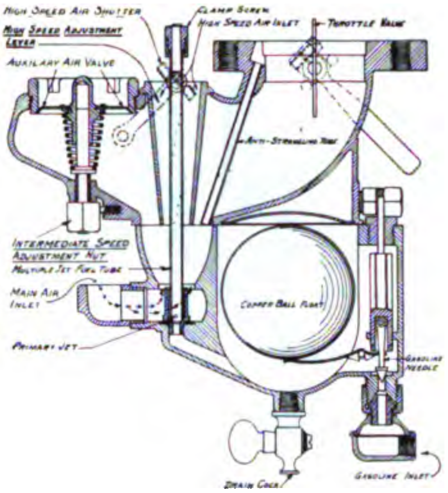


Fig. 1—Carter Carburetor, Model C Multiple Jet Type.

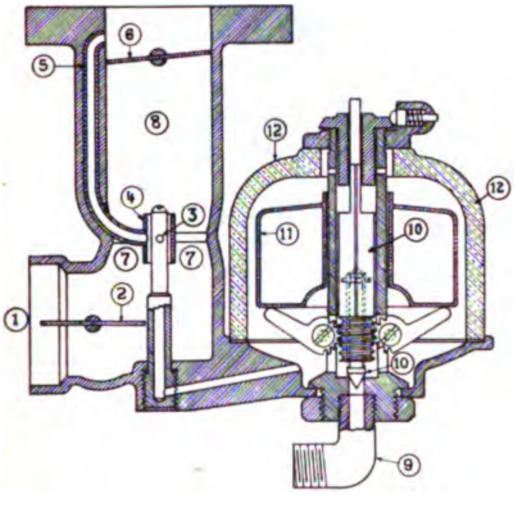


Fig. 2—Carter Carburetor Model E. Single Jet Type showing novel By-pass around throttle and Adjustable Gravity Needle Float Mechanism.

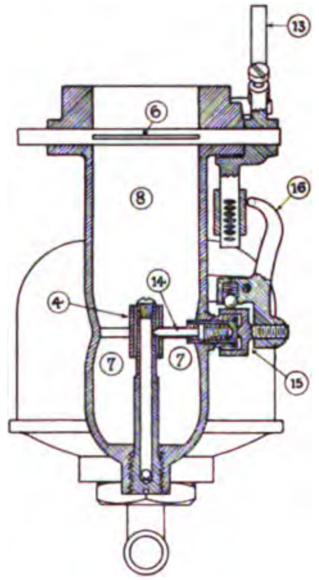


Fig. 3—Same as Fig. 2. showing mechanically operated Needle (14) Lever Working in conjunction with Throttle (13) through mechanism (16) and (15.)

MODEL E, Fig. 2 and 3.

This carburetor is designed for small and medium sized four cylinder motors. The principal novelty in its construction lies in the Low Speed Air Duct, (5) which terminates at its upper end above the throttle (6) and at its lower end in an open-ended copper sleeve (4) surrounding the spray nozzle (3.)

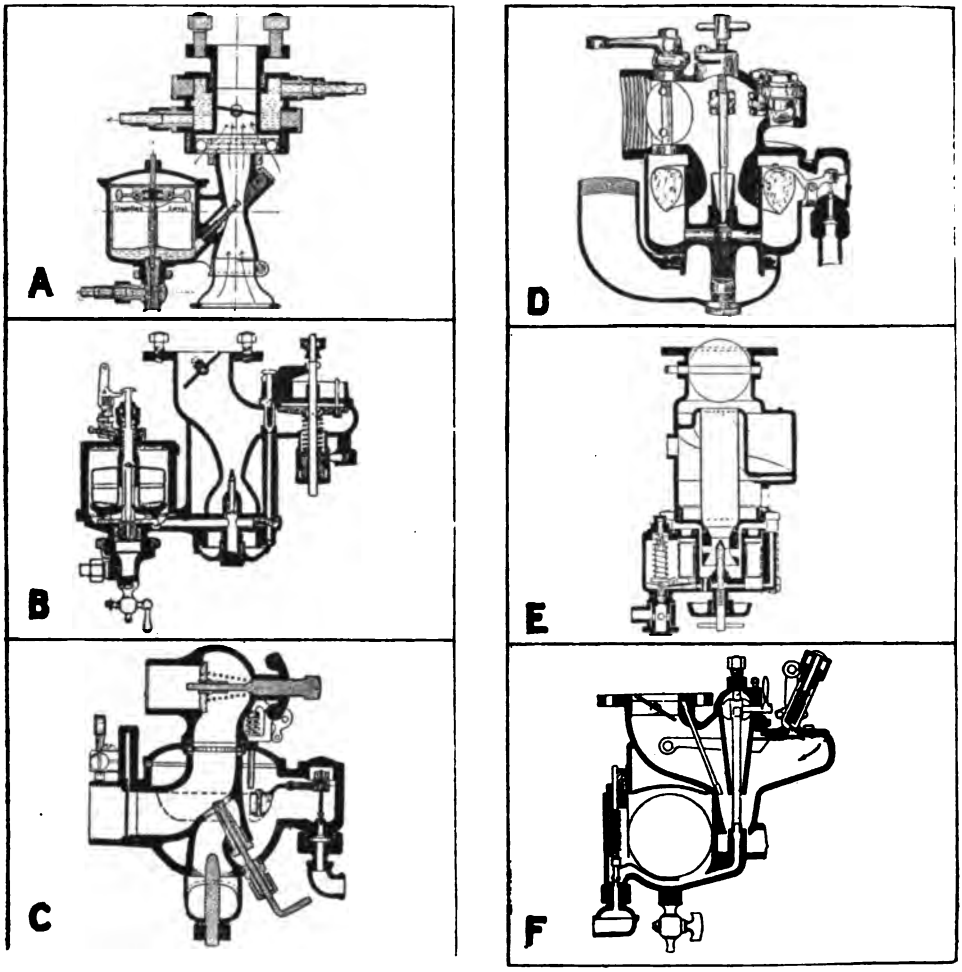
At low speed, with the throttle closed or practically closed, the mixture passes through this Duct (5) furnishing a perfect gas. This Duct and sleeve comprise in themselves a small carburetor for low speed work, while the main or large air passageway (7) and (8) supplies gas for the higher speeds.

The needle (14) mechanically connected to the throttle mechanism, (13), (16) and (15) regulates the size of the spray nozzle (3) in conformity with the various throttle openings, and the simple adjustments thereof allow the carburetor to be quickly set for all speeds on any motor.

It is interesting to note that there are no springs whatever to adjust on this instrument. The float chamber (12) comprises a heavy gravity needle (10) with a copper float (11) concentric. The entire mechanism is enclosed by flint glass, cup-shaped, and ⅛ inch thick. The advantage of this is apparent.

Air Inlet	1	Gasoline Connection	9	Throttle Lever	13
Easy Starting Shutter	2	Gravity Needle	10	Spray Jet Regulating Needle	14
Mixing Chamber	8	Flint Glass Float Chamber	12	Needle Adjustment	15
		Needle Control Mechanism	16		

CHART No. 60A.

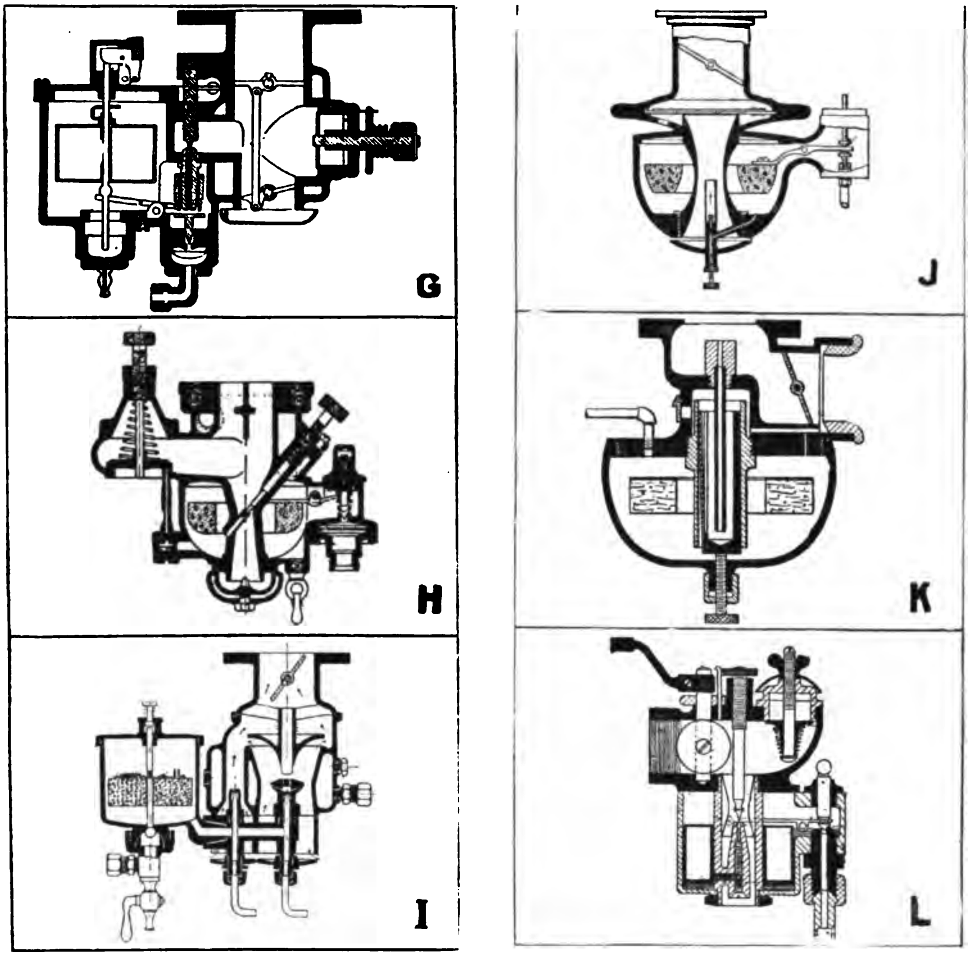


A—G & A Carburetor with inclined jet.
B—Stromberg Carburetor with double jet.
C—Schebler Carburetor.
D—Kingston Carburetor.
E—Vortex Carburetor.
F—Carter Carburetor.

A—Side float. Single jet. Venturi. Ball control of auxiliary valve.
B—Side float. Double jet. Venturi. Spring controlled auxiliary air valve.
C—Concentric float. Spring controlled auxiliary air valve. Single jet.
D—Concentric float. Ball controlled auxiliary air valve. Single jet.
E—Concentric float. Single jet.
F—Side float. Multiple jet. Spring controlled auxiliary air valve.

A Comparison Study of a Few of the Leading Types of Carburetors.

CHART No. 61.



G—Rayfield Carburetor.
H—Holly Carburetor.
I—Willet Carburetor.
J—Bowers Carburetor.
K—Stewart Precision Carburetor.
L—Breeze Carburetor.

G—Side Float. Single Jet. Spring controlled auxiliary Valve.
H—Concentric Float. Single Jet. Spring controlled auxiliary Valve.
I—Side Float. Double Jet.
J—Concentric Float. Single Jet.
K—Concentric Float.
L—Concentric Float. Venturi Tube.

A Comparison Study of Several Leading Carburetors.

CHART No. 62.

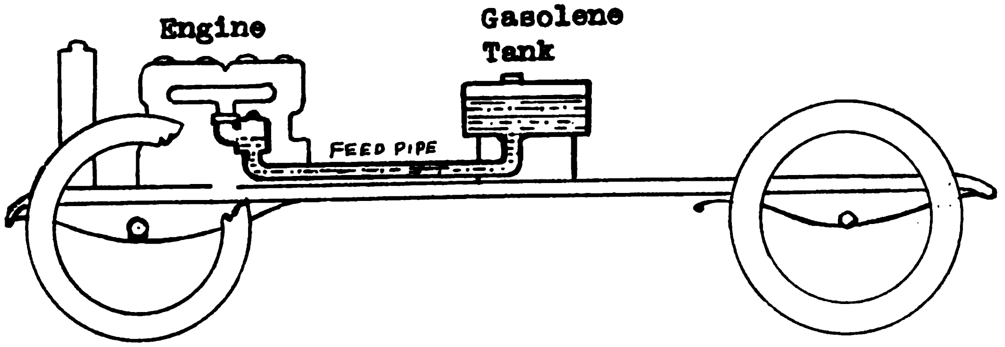


Fig. 1—Gravity Feed System.

Gasoline from tank to carburetor flows by gravity.

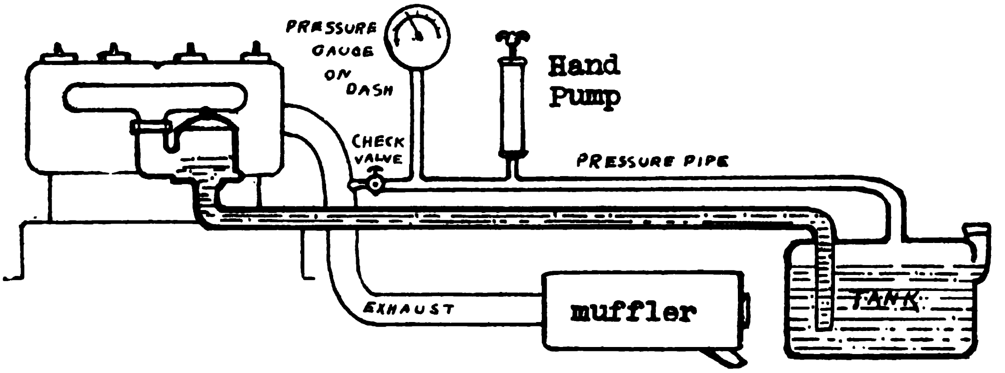


Fig. 2—Pressure Feed.

— Gasoline forced to carburetor from tank. Pressure supplied by hand pump to start and then from exhaust.

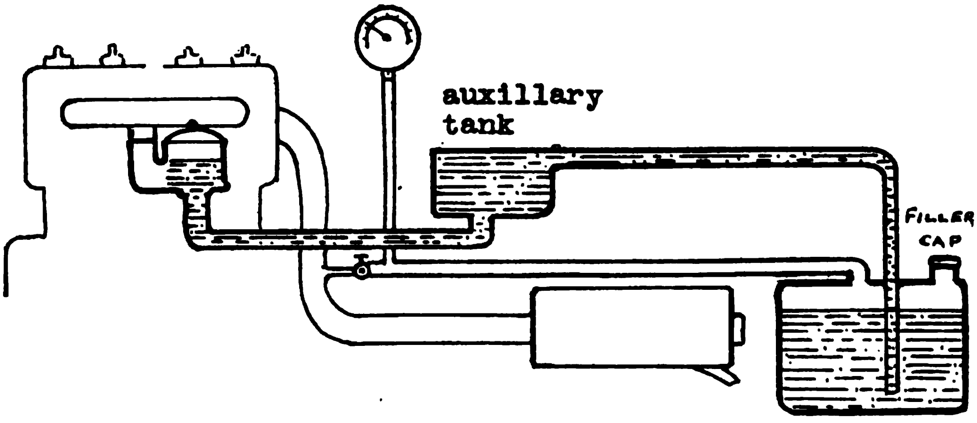


Fig. 3—Gravity Feed From Auxiliary Tank.

Gasoline carried to auxiliary tank by pressure. Pressure supplied by exhaust.

Illustrating the Different Methods for Feeding Gasoline to the Carburetor from the Tank.

CHART No. 63C.

GASOLINE FEEDS.

The Supply of Gasoline for an automobile engine is carried in a tank made of sheet copper or galvanized iron, the joints being made as tight as possible to prevent leakage.

It Is Filled Through An Opening in the top, closed by a brass plug that screws in.

There Are Two Systems of leading the gasoline from the tank to the carburetor; GRAVITY FEED AND PRESSURE FEED.

GRAVITY FEED.

In This, the tank is placed well above the carburetor, so that the gasoline flows from one to the other by gravity. Chart 63C, Fig. 1.

The Feed Pipe Is Small, and made of brass or copper.

It Is Connected to the lowest point of the tank, and projects slightly above the bottom, so that impurities will settle and not be carried to the carburetor.

The Tank Is Usually Placed Under the Seat, so that for filling it is necessary to remove the cushion.

In the Filling Cap there is a small hole, by which air may enter the tank to take the place of the gasoline drawn off.

If the Car Always Runs on Level Roads, the gravity system is satisfactorily, but in ascending hills, the car might be at such an angle that the tank would be below the level of the carburetor, which would prevent the gasoline from flowing.

The Steady Flow of Gasoline might also be changed by the car running on the side of a ditch, or with the wheels on one side in a deep rut, bringing one side of the car lower than the other.

For a Short Car, where the tank is close to the carburetor, the gravity system is successful, for the car could not be tipped enough to stop the flow without turning over.

Long, High Powered Cars require a different system, in order that the gasoline feed may be steady at all times.

PRESSURE FEED.

In the Pressure Feed System, the tank is air-tight, and a pressure is maintained in it, so that the gasoline is forced out just as seltzer water is forced out of a siphon bottle.

The Gasoline Tank may be in any position on the car, and is usually under the rear end of the body, being filled from the back. (Chart 63C, Fig. 2.)

A Small, long pipe, exposed to the air, cools the gas so that there is no danger of this happening.

The Tank Is Connected to the Exhaust Pipe of the engine, so that part of the pressure of the exhaust gas is carried to it by a small pipe.
The Pipe Must Be Small and of good length, for if it were short and large, the gas might reach the tank as a flame, setting fire to the gasoline.

In Starting the Engine, when there is no pressure in the tank, an air pump, usually placed on the dash, is used.

This Pump Is Connected to the Pressure Pipe, and a few strokes of it will give enough pressure to start the car.

When Started, the exhaust from the engine maintains the pressure.

A Guage on the Dash indicates the pressure in the tank, and leaks are shown by a drop of the pointer.

The Pressure is held in the tank, and prevented from escaping when the engine is stopped, by a check valve placed in the pressure pipe this is also a relief valve, acting like a safety valve, for if the pressure gets to a point that might strain the tank and connections, it blows off.

The Filling Cap must be tight, as well as all of the connections, to prevent leakage of the pressure.

PRESSURE FEED AND AUXILIARY TANK.

In Some Cars, a small auxiliary tank is placed on the dash, fed with gasoline by pressure.

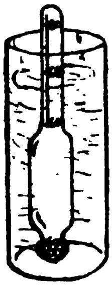
This Is so High Above the Carburetor that no ordinary tipping of the car could stop the flow; the carburetor being fed from it by gravity. Chart No. 63C, Fig. 3.

The Gasoline in the Auxiliary Tank makes an air pump unnecessary for it holds enough gasoline for a few miles of running.

The Proportion of Gas and Air best for carburetors of average temperature is 1 PART GAS and 18 PARTS AIR.

GASOLINE LOW GRADE AND HIGH GRADE, AND EFFECT ON A CARBURETOR.

RESULTS OF USING LOW GRADE OF GASOLINE



A Gasoline Hydrometer for testing the gravity of gasoline.

A Low Grade of Gasoline Will Produce poor results in any carburetor.

Weak Explosions, regular but weak, may be due either to a too rich or too poor a mixture.

Difficulty in Starting is also traceable to low grade gasoline.

Engine Will Sometimes Miss Fire and not develop its full power.

Inferior Gasoline Is Generally Indicated by a smoky exhaust and disagreeable odor.

A Compound Known as "Inter-Lube," an internal lubrication, the makers claim, if mixed with the gasoline will prevent carbonization.

HOW TO TEST GASOLINE

Suitable Gasoline for automobile use should test 76 degrees.

To Test With a Gasoline Hydrometer (secure one at any auto supply house), fill the glass tube with the gasoline, insert the hydrometer, which will float.

The Gravity of the Gasoline Is Determined by the Depth the hydrometer sinks in the gasoline.

A Scale Is Graduated on the Upper Portion of the Hydrometer and the level of the gasoline indicates the specific gravity.

The Scale Usually Runs from 60 to 80.

Gasoline Under 60 test ought not to be used.

About 68 test is the usual gravity test of gasoline obtained at the grocery store.

A Gravity Test of About 72 to 76 would be better, especially in winter.

Full Instructions generally accompany the Hydrometers, with directions and explanations.

Note.—The test is supposed to be made when the temperature is at 60; if a lower or higher temperature in the atmosphere, this will make a difference in the test.

A TEST BY HAND.

In the Absence of a Hydrometer, pour a little gasoline in the hand.

When It Evaporates Slowly and leaves a greasy deposit, it should be rejected.

When It Evaporates Rapidly and leaves the hand dry and clean, it is acceptable.

This furnishes a fairly reliable test.

WATER IN GASOLINE

Is Indicated, generally, when the engine runs irregularly and finally stops.

This Will Often Prevent Starting of the engine.

Water Is Frequently Present in Gasoline, and, particularly when the tank is low, is liable to get into the pipes and carburetor.

The Drain Cock at the bottom must be opened to let off the water that settles from the gasoline.

The Natural Result of Water in the Carburetor is impaired or interrupted vaporization of gasoline.

In Cold Weather, also, this water is liable to freeze, preventing the action of the carburetor parts. Ice in the carburetor can be melted only by the application of hot water, or some other non-flaming heat, to the outside of the float chamber.

FLOODING OF A CARBURETOR

May Be Caused by dirt under the float valve; this may often be removed by depressing the float, thus opening the float valve.

A Leak in a Float will also cause flooding.

GASOLINE OUGHT TO BE STRAINED.

Many Carburetor Troubles Would Be Avoided if more care were taken to free gasoline of all dirt before its entrance into the tank.

When Filling the Tank use a strainer funnel.

Chamois Skin makes an excellent filter; if a wire gauze be used it should have a very fine mesh.

In the Absence of a Strainer Funnel, use three or four layers of fine linen fitted inside an ordinary funnel.

Never Use the Same Funnel for both gasoline and water.

OLD GASOLINE

Left in Carburetor for Some Time, when car is not in use, will lose its strength.

If the Engine Should Not Start easy, then drain the float chamber.

BACK KICKING AND BACK FIRING OR POPPING IN THE CARBURETOR.

There Seems to Be Much Confusion in the use of the terms "back kick" and "back fire," the latter being very often used to describe what happens when, in starting a motor, it suddenly reverses its direction of rotation to give a "back kick."

Generally Speaking, back-firing is caused by weak mixture which burns so slowly that the frame continues until the opening of the admission valve again, when it ignites the incoming charge in the intake pipe and shoots back to the carburetor. While an over-rich mixture will also burn slowly, it rarely ever will cause back-firing.

Another Cause of Back-Firing is, of course, the faulty timing of the valves, or, in fact, a badly leaking valve. So much for back-firing. Back-firing is caused by the preignition in starting the motor, which is due usually, as is well known, to too much "advance" in the spark timing.

A Cause of Missing at Slow Speeds.—Erratic firing at slow engine speeds, especially when running light, may be caused by a leaking of air into the cylinder between the carburetor and the combustion chamber. This is due to worn valve stems and valve guides, and the leaking is, of course, accentuated when the throttle is closed.

A Probable Explanation of the engine's running slower on battery ignition when this condition exists is that, owing to its being possible to retard the spark more with this system, one is able to keep the throttle further open, thereby diminishing the tendency to draw air in past the valve stems.

THE GASOLINE TANK.

The Tank of a Gravity Feed System is always provided with a small hole, usually drilled through the filling cap, by which air may enter to replace the gasoline as it is drawn off.

If This Hole Becomes Plugged with dirt the gasoline in flowing out will tend to create a vacuum, and the flow will stop.

This Trouble Is Difficult to Locate, for it has the symptoms of a lack of gasoline.

Opening the Cap to see whether the tank is empty will admit more air, and the motor will again run, slowing down and stopping when the condition again exists.

Clearing the Vent Hole removes the trouble, which is spoken of as an air-bound tank.

The Outlet Pipe Should Project slightly above the bottom of the tank, so that water and dirt may settle, and not be carried to the carburetor.

All of the Joints of the Gasoline Line should be screwed and well put together.

Gasoline Rots Rubber rapidly and should not be carried through a rubber hose, nor should joints be packed with rubber.

Shellac or Soap May Be Used when screwing joints together, as it helps to make them tight.

The Lowest Point of the Gasoline Line is usually at the carburetor and should have a cock or plug so that the system may be drained.

CARBURETOR TROUBLES.

Beside the Possibility of Getting Out of Adjustment, the great trouble with a carburetor comes from the passages getting clogged with dirt. Threads of cotton waste getting in the tank will stick in the valve so that the carburetor will flow.

Anything That Obstructs the Flow of Gasoline will make the engine run unevenly or stop.

The Construction of the Carburetor should be learned, so that it may be easily taken apart for cleaning and put together again correctly.

In Taking It Apart, remember the position of the gasoline and adjustments or mark them, so that they can be approximately replaced without losing time in readjustments.

IF THE FLOAT VALVE IS CLOGGED

So That It Will Not Close, the carburetor will flood, causing too rich a mixture.

The Needle Valve May Wear Sufficiently to Cause This, in which case it should be reground, the operation being similar to that of grinding an engine valve.

Another Cause for a flooding carburetor is a leaky float, or a cork float that becomes soggy.

Gasoline Corrodes Brass and copper slightly, and in time may cut a hole through a metal float and enter.

This, of Course, Makes the Float Heavier than it should be, and as it will not float high enough on the gasoline, the valve will not close soon enough. The hole may be too small to be seen easily, but when the float is shaken the gasoline may be heard splashing inside.

The Soldered Joints of the Float May Also Break, admitting the liquid. The hole may be too small to pour the gasoline out of, and the best way to get it out is to place the float in hot water. The heat will vaporize the gasoline, and it will come out in the form of bubbles of vapor.

When the Float Is Empty the Hole Should Be Plugged with solder, using as little as possible, and scraping off the surplus, that the weight of the float may be changed as little as may be.

Care Should Be Taken That a Cork Float Does Not Chafe in rising and falling, for the dust of the shellac or varnish thus rubbed off may choke the spray nozzle.

SUMMARY.

The following summary of carburetor troubles, the remedy for each of which is mentioned in the foregoing, may be of value for qui reference and for refreshing the memory:

Mixture Too Rich: Too much "priming."

Too much gasoline.

Punctured float.

Float valve not working properly, owing to bent needle, or presence of foreign matter in valve seat.

Primary air passage clogged or partially obstructed.

Air valve not wide open.

Mixture Too Weak: Insufficient "priming."

Carburetor passages clogged.

Filtering gauze covered with dirt.

Throttle valve out of adjustment.

Insufficient flow of gasoline.

Tank valve closed.

Break in gasoline supply.

Starting crank turned too slowly.

Bad gasoline; originally, or from standing.

Water in gasoline.

Carburetor too cold.

Gasoline supply exhausted.

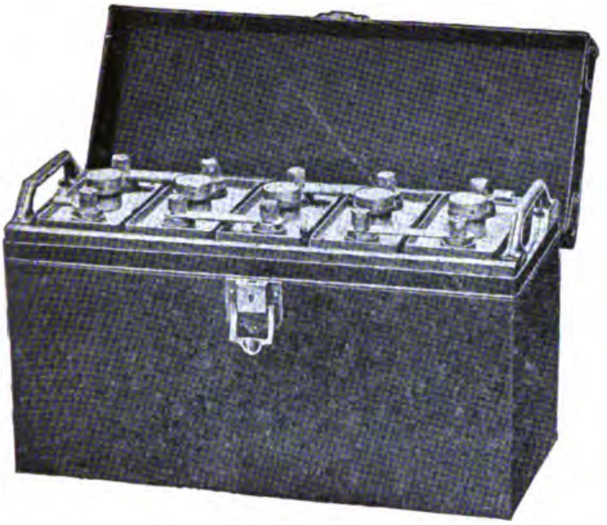


Fig. 2—The Ignition Storage Battery; A Chemical Generator of a "Direct" Flow of Electric Current. Contained in a battery box. Sometimes called an accumulator.

The Storage Battery will also supply electricity to operate a Jump Spark or High Tension System of ignition or a Low Tension "Make and Break" system. The Storage Battery for ignition consists of three cells placed in an acid proof box. (See instruction on storage batteries.)

These cells are covered over with a hard rubber or coal tar composition, leaving the lead lugs projecting. These lugs connect one cell to the other and two ends are left "open," one a "Positive" or North, and the other a "Negative" or South. They are called "Positive" or "Negative" Terminals. Wires are connected to these terminals and the current is conducted over the wires to the ignition system.

When the Storage Battery is "run down" it is "recharged" by attaching wires from electric wires to the Terminals (will be explained later.)

The cells contain lead plates and are immersed in an acid solution.

Three cells give 2 volts each and are usually placed in a box and connected together making a total of six volts, this being the usual pressure required to operate a coil.

Above battery is an Edison Type of Battery. This type gives but 1½ volts per cell.

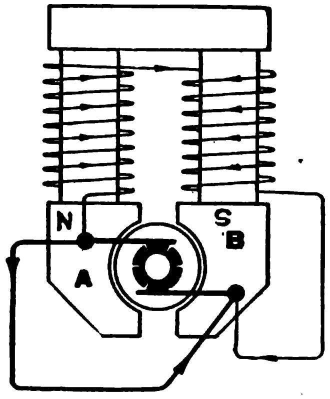


Fig. 3—The Dynamo; A Low Tension, Mechanically Generated, Direct Flow of Electric Current. The Dynamo will supply electricity to operate the coil of a Jump Spark or High Tension system of ignition or a low tension "Make and Break" system, but is not now in use on automobiles to any great extent.

The Dynamo is more adapted for Stationary Gasoline or Marine Engine use where the speed does not vary so much.

The Dynamo has an "Electro-Magnetic" Field, meaning that the "field" is magnetized only when the armature is revolving.

The Magneto has a "Permanently" magnetized field and will be described later.

The Dynamo generates a "Direct" or continuous flow of electricity, meaning the current flows continuously from the "North Pole" to the "South Pole," whereas the current in a magneto is reversed alternately from North to South and South to North and flows "alternately" and is not a direct flow.

The magneto is used in a different manner and is a separate and distinct system of ignition and will be described later.

The Dry Cell Battery (A Primary Cell); A Chemical Generator of a Direct Flow of Electric Current will also supply electricity for ignition but is not reliable. Continuous use of dry cells will exhaust them or run them down rapidly and the pressure drops accordingly and thereby causes a "weak" spark This battery will recuperate however if left standing for a while unused.

The dry cell battery is better adapted for ringing door bells or telephone work where the work required is not continuous.

The dry cell contains no liquid but merely moisture, hence its name; Dry Cell Battery.

Six cells connected in a series connection is usually the combination for a set for ignition.

Three Sources of Supplying Electricity.

To operate a Jump Spark Coil System of ignition, the electricity may be generated from a Dynamo, Storage Battery or a set of Dry Batteries.

No reference is made here to Magnetos, this comes later, under a heading of its own.

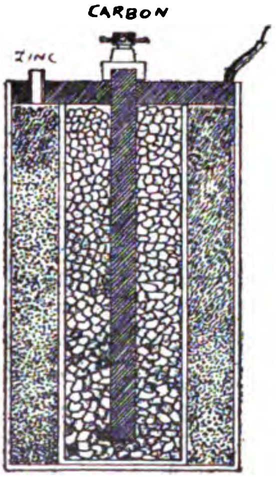


Fig. 4.
Sectional View of a Dry Cell.

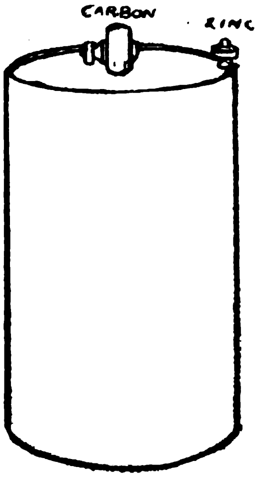


Fig. 4.
Complete View of a Dry Cell.

Chemical and Mechanical Generators of a "Direct" Flow of Electricity.

CHART No. 64.

INSTRUCTION No. 13.

ELECTRICITY: Electric Ignition. System of Ignition. Low Tension System.

ELECTRIC IGNITION.

Electric Ignition is now used on very near all gasoline engines, and in general presents more difficulty to the operator than any other part of the mechanism, because of the fact that electricity is so little understood.

The First Method for Igniting the Gas in a gasoline engine was by the means of a "hot tube" or flame, but this method now being obsolete, we will deal only with the electric ignition.

Before Going Into the Details of the various systems of ignition a brief explanation of the action, effect and handling of an electric current will be given, and should be well understood before proceeding.

ELECTRICITY.

What Electricity Is, is not known, but the way it may be produced, its handling and control, and the uses to which it may be put are well understood.

Electricity Produced in one place may be transmitted to another place, provided a path is arranged so that it may return to where it started.

It Will Not Flow if there is no circuit; that is, a continuous path.

If the Circuit is Broken, the flow will immediately stop, and will not start again until the circuit is once more completed.

Copper Wire is Usually Used to take the electric current from where it is produced to the place where it is to be used, and another wire may be used to bring it back again, the first wire being called the LEAD, and the second the RETURN.

If There is Any Way in Which the Current May Leak from the lead wire and return to the starting point without going through the entire circuit, it will do so, and this leakage is called a SHORT CIRCUIT.

Anything That Will Permit a Current of Electricity to Pass Through It is called a CONDUCTOR: all metals are conductors.

Substances Such as Rubber, china and glass, wood fibre, mica, are called NON-CONDUCTORS, or INSULATORS.

A Wire is Insulated to prevent the current of electricity from leaking off by wrapping it with cotton or silk, which is soaked with rubber, to prevent dampness from getting in.

When Dry, Cotton and Silk are Insulators, but as water is a conductor, damp cotton and silk cease to be insulators.

While All Metals are Conductors, some are better conductors than others; a copper wire, for instance, will pass a larger current than an iron wire of the same size.

If a Wire Has More Electricity Passed Through It than it can easily conduct, heat will be generated, and it may get so hot that it will melt.

The Larger a Wire Is, the larger is the current that it can pass without heating.

Copper is in most general use as a conductor of electricity, because it will permit larger currents to pass than almost any other metal; silver is a better conductor, but cannot be used because of the expense.

EXPLANATION OF VOLTAGE AND AMPERAGE.

A Current of Electricity Flowing in a Wire May Be Measured just as a current of water flowing in a pipe may be measured. (See Chart 76.)

The Amount of Water That Flows Through a Pipe depends on the pressure, or head, and the volume of electricity that flows through a wire depends on the pressure at which it flows.

The Pressure of a Current, or the FORCE with which it flows, is measured in VOLTS.

Thus a Current of Ten Volts is flowing with a pressure of that amount, just as water in a pipe might be flowing at a pressure of ten pounds.

The Volume of the Current or quantity of it, is measured in AMPERES.

Electricity Will Flow More Easily through some conductors than through others because there is a difference in their RESISTANCE to the current.

Everything Presents More or Less Resistance to the flow of a current, and the less resistance that a substance presents, the better a conductor it is.

The Greater the Resistance, the less current can pass; the pressure of the current will not change but the volume will be reduced.

In Forcing a Current Through Such Resistance, heat is produced, and the greater resistance the greater will be the heat.

POSITIVE AND NEGATIVE TERMINALS

Every Generator of Electricity Has Two Terminals, that being the name given to the points from one of which the current leaves and to the other of which it returns.

The Current Always Flows in the Same Direction; from the POSITIVE POLE to the NEGATIVE POLE; it leaves the generator by the positive pole and returns by the negative.

ELECTRICITY IS MADE TO DO WORK.

The Current Only Flows When the two Terminals, or poles are connected by a conductor.

A Current Will Flow if Any Opportunity is Presented; if there is no regular conductor, moisture will often make the connection.

Because of This Desire to Flow, the current may be made to perform work.

If the Circuit Includes an Electric Lamp or Bell, the current in flowing through the circuit from the positive pole to the negative is made to light the lamp or ring the bell.

The Circuit, with the lamp or bell, presents a resistance to the flow of the current, and if there is a short circuit that presents less resistance the current will return by it instead of going through the lamp or the bell.

Therefore the Circuit Must Be So Arranged that the current cannot return to the generator or without doing the work set for it.

SYSTEMS OF IGNITION.

While There are Several Methods of Producing the Spark in the Cylinder at the proper instant, they consist in general of the same parts.

In the First Place, there must be a GENERATOR to supply the current of electricity; spark plugs or sparkers. also called IGNITERS, in the cylinder, at which the spark is produced; a TIMER, by which the exact instant of the spark may be controlled, and the CIRCUIT, consisting of the necessary wires or conductors.

Whatever the System May Be, the current is produced by some kind of generator, and therefore a description of generators will be given before describing the systems.

METHODS OF GENERATING "DIRECT" FLOW OF ELECTRIC CURRENT.

A Current of Electricity May Be Generated by chemical means, by CELLS, (Fig. 2 and 4 Chart 64) or mechanically, by a MAGNETO or DYNAMO. See Chart 64, Fig. 3. (The Magneto will be described further on as it generates an "Alternating" current.)

CELLS.

Cells are of Two Kinds, PRIMARY and SECONDARY; primary cells actually MAKING the current, and secondary cells STORING the current and giving it out as needed.

DRY CELLS (PRIMARY CELL) A CHEMICALLY GENERATED (DIRECT CURRENT.)

The Primary Cells used for automobile work are called DRY CELLS, and consist of zinc cups, in which are placed sticks of carbon. (See Chart 64, Fig. 4.)

The Cups are Lined with some substance like blotting paper, and the space between the carbon stick and the cup is packed with bits of carbon and the necessary chemicals.

The Blotting Paper and Carbon Bits are Moistened with the proper solution, and the top of the cup sealed with tar, so that it is watertight.

The Zinc Cup and the Carbon Stick each have a thumb nut at the top, called a BINDING POST, to which the wires are attached.

When the Circuit is Formed, the current of electricity flows from the carbon binding post over the circuit and back to the cell by the zinc binding post, the CARBON being the POSITIVE POLE, and the ZINC the NEGATIVE POLE.

Dry Cells Have a Pressure, or Voltage, of about 1½ volts, and the volume of the current they produce, called the AMPERAGE, depends on the size of the cell.

When in Use a Primary Cell Becomes Exhausted, and the voltage drops gradually.

When it has reached a point Where It Does Not Give Sufficient Current, it must be thrown away, and new ones used.

STORAGE BATTERY (SECONDARY CELL) CHEMICALLY GENERATED (DIRECT CURRENT).

Secondary Cells, Also Called Storage Cells, or ACCUMULATORS, are filled with current from a lighting current, and may be recharged with electric current when exhausted. (See Chart No. 64, Fig. 2.)

A Storage Cell Is Made of Prepared Lead Plates, placed in jars made of hard rubber or celluloid, and filled with a solution of sulphuric acid and water, called the ELECTROLITE. (Storage Batteries are described in detail further on.)

The Jar is Filled With Electrolite until the plates are covered, a cover preventing it from spilling.

A Hole in the Cover, closed with a plug, is used for examining the condition of the cell, and refilling it when necessary.

Through Evaporation, leakage or spilling, the level of the electrolite may get below the top of the plates, in which case the jar should be refilled, enough electrolite being added to bring it to the correct level.

Electrolite is made by adding one part of chemically pure sulphuric acid to from three to four parts of pure water—distilled if possible.

An Instrument Called a Hydrometer is used to get the right solution, and when floated in the solution its scale would read about 1200.

A Hydrometer may be obtained from the makers of the battery.

The Terminals of a Storage Cell are always marked with signs to indicate the poles; a PLUS SIGN, the same that is used in arithmatic, being the POSITIVE POLE, and a MINUS SIGN being the NEGATIVE POLE.

The Poles Are Often Painted as well, red being the positive and black the negative.

A Storage Cell Requires Careful Handling, especially when being charged, and as it will require charging only three or four times during a season, it is better to have it done by an expert than to risk damaging it by incorrect charging.

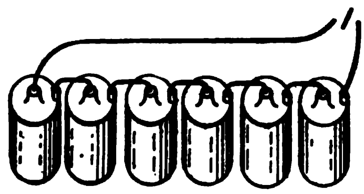


FIG. 1 SERIES

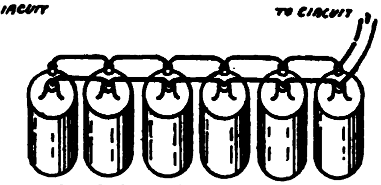


FIG 2 PARALLEL

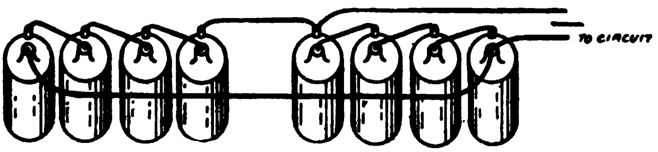


FIG 3 MULTIPLE

METHOD OF CONNECTING DRY CELLS.

Fig. 1—Is the usual method—This method gives the voltage of 6 cells and an amperage of one cell.

Fig. 2—Is seldom used—This method gives the voltage of but one cell and an amperage of six cells.

Fig. 3—Is a method used for emergency. In this case the reader will suppose that two sets of dry cells supply the current for ignition; one set is used for awhile then the other—if both sets run down then connect them in multiple as shown above. This method gives a voltage of four cells and an amperage of two cells.

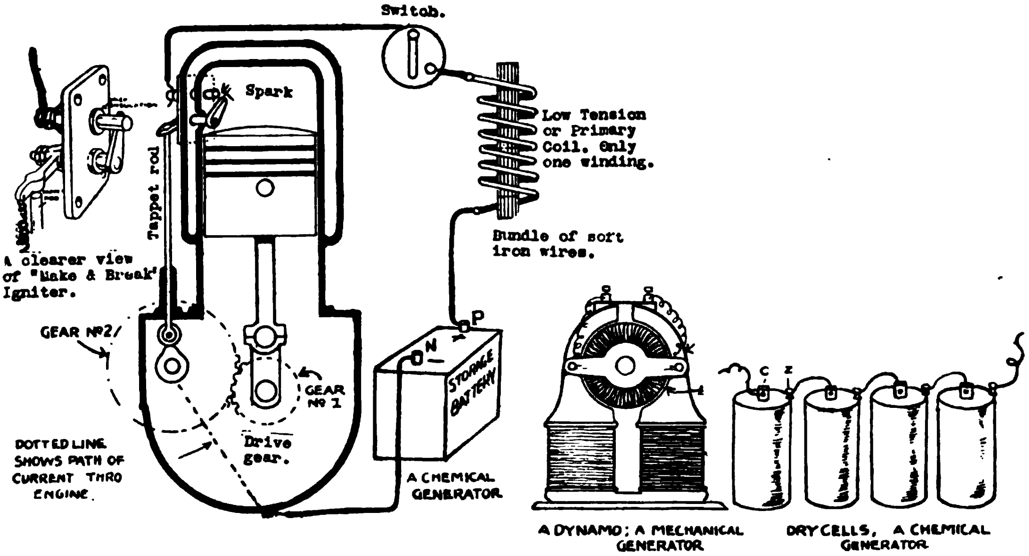

Switch.
Spark
Tappet rod
Low Tension or Primary Coil. Only one winding.
Bundle of soft iron wires.
A clearer view of "Make & Break" Igniter.
GEAR No2/
GEAR No 1
Drive gear.
DOTTED LINE SHOWS PATH OF CURRENT THRO ENGINE.
N
P
STORAGE BATTERY
A CHEMICAL GENERATOR
C
Z
A DYNAMO; A MECHANICAL GENERATOR
DRY CELLS, A CHEMICAL GENERATOR

Fig. 4—A Make and Break Low Tension System of Ignition showing Direct Current Generators, either of which may be used.

The Igniter is shown which makes and breaks the low tension current as it flows from the positive pole of the battery to the single wound low tension coil through switch(switch shown open by mistake) then to inmeated electrode.

When the Nose of the Cam strikes the tappet rod, this rod makes and breaks the flow of current and creates a flash or spark. The current flows from negative pole of battery to ground on engine, thence through metal of engine to lower electrode.

The Dynamo or the Storage Battery or the Dry Cells either would supply the current for the "Make and Break" Ignition. In fact any low tension direct flow of current would supply electricity for this system. A low tension magneto would also, but magnetos will be treated later. A magneto does not give a steady "direct" flow of current as the above generators, but gives an "alternating" flow of current. In other words the flow of current from above generators is always from positive to negative, whereas the magneto flow of current alternates from positive to negative rapidly. For this reason magneto ignition will come under a separate heading and "direct" current generators only, will be treated here.

A Storage Cell Has a Voltage of a little over 2 volts, and this will drop slowly to 1¾ volts, when it requires recharging.

In this it is like water running out of a tank; when the tank is empty it is necessary to refill it.

CELL CONNECTIONS.

One Cell Will Not Give Enough Current to Produce the Spark required to ignite the mixture, and therefore two, three, four or more are used, connected together.

SERIES CONNECTION.

The Most Usual Form of Connection is in Series; the negative pole of one cell is connected to the positive pole of the next, so that the current from one cell must pass through all of the others in order to return to where it started. (See Chart 65, Fig. 1.)

This Method of Connecting Increases the Voltage as many times as there are cells; for instance, if there are four cells of 1½ volts each, the voltage of the Battery of cells will be six volts.

The Volume or Amperage, does not change, being the same that it is for one cell.

PARALLEL CONNECTIONS.

Another Method of connecting is in PARALLELL; all of the positive poles are conected to one wire, and all of the negative to another. (See Chart 65, Fig. 2.)

This Gives the Same Voltage (Pressure) as one cell, but increases the amperage (quantity) as many times as there are cells.

MULTIPLE CONNECTION.

A Third Method, much in favor, is to connect the cells IN MULTIPLE. (See Chart 65, Fig. 3.)

In This, the cells are divided into two equal groups, each group being connected in series, and the two groups being connected with the circuit in parallel with each other.

This Gives a Voltage of One-Half what it would be if all were connected in series, and an amperage of one cell multiplied by the number of groups.

A DYNAMO OR MECHANICAL GENERATOR.

A Mechanical Generator, which is driven by the engine, produces a current of electricity, and its action depends on MAGNETISM.

Magnetism is the property sometimes possessed by iron or steel, by which they attract other pieces of iron or steel.

A Generator consists of two parts; the FIELD, which produces magnetism, and the ARMATURE which revolves in the magnetism, and produces the current of electricity. (See Fig. 3, Chart 64.)

The Field is Made in Two Ways; it is either a PERMANENT MAGNET, that is, steel that is magnetized so that its magnetism does not change, or an ELECTRO-MAGNET; that is, wire wound around a soft piece of iron, which is a magnet only while electricity is flowing through the wire.

When the Field is a Permanent Magnet, the generator is called a MAGNETO; when the field is an electro-magnet, the generator is called a DYNAMO. (See Chart 64, Fig. 3.)

The Armature is a Piece of Soft Iron, with insulated wire wound around it endways.

The Voltage of a Magneto or Dynamo Depends on the Size and Quantity of Wire Wound on the Armature, and on the speed.

Mechanical Generators Usually Have But One Terminal, the other being GROUNDED, which will be explained.

Where There Are Two Terminals, they are marked as the terminals of a storage cell are marked.

As the Care of a Mechanical Generator requires a thorough knowledge of electrical engineering, it is far better to send it back to the makers in case it is damaged, than for an inexperienced man to attempt to repair it.

GROUNDING THE CIRCUIT.

When the Current of Electricity is Required to do Work, as, for instance, the producing of a spark in the cylinder, it must be taken to the spark plug, or igniter through a coil, by means of a wire, but may be returned to the generator by means of a GROUND. (See Chart No. 65, Fig. 4, dotted lines show path of current through metal of engine.)

The Frame and Engine of an Automobile are Made of Metal, and therefore will conduct electricity.

If the Negative Pole of the Generator is Attached to the Metal Frame or engine, and a wire attached to the positive pole, the current will flow in the circuit when the positive wire is touched to any other metal part of the frame or engine, for the metal acts as a conductor and permits the current to return to the generator.

This Method Saves Wire, for wire is used only to take the current to where it is needed, the metal of the frame or engine bringing it back again.

For Electrical Reasons that need not be explained here, the negative pole is always the one that is grounded, never the positive, (See Fig. 4, Chart 65.)

SWITCHES.

When the Current for the Ignition is Supplied by Battery, it is usual to have two sets (Fig. 1, Chart 66). When a magneto or dynamo is used, usually a battery is also provided, the extra source of current being available in case of failure of the regular source.

A Switch is placed in the circuit, so that either may be used.

Switches are Made in Many Forms, but the most usual is a flat piece of spring brass, pivoted at one end, so that it may swing from side to side.

The Free End May Touch Either of Two Knobs of Brass, one on each side, or be between them without touching them.

Each of the Knobs is Connected to One of the Sets of Battery, or

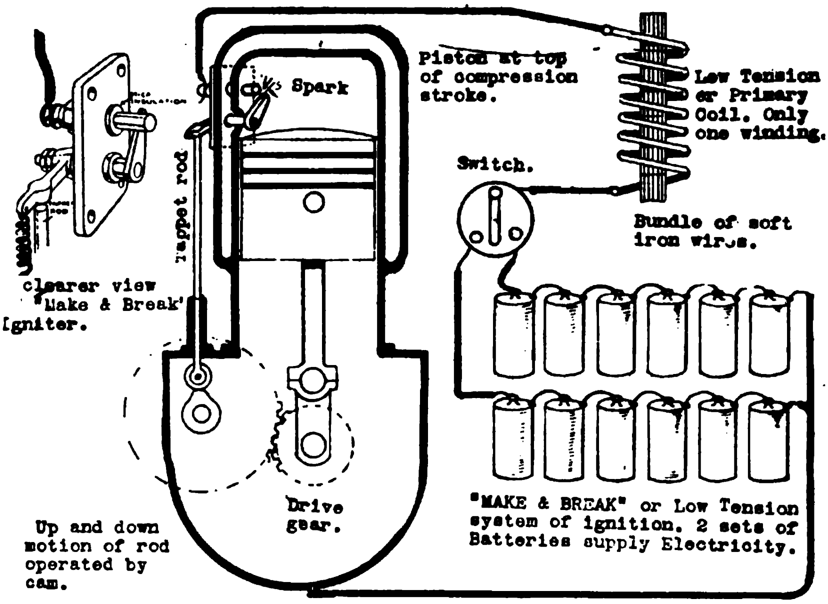

Piston at top of compression stroke.
Spark
Low Tension or Primary Coil. Only one winding.
Switch.
Bundle of soft iron wires.
Tappet rod
clearer view "Make & Break" Igniter.
Up and down motion of rod operated by cam.
Drive gear.
"MAKE & BREAK" or Low Tension system of ignition. 2 sets of Batteries supply Electricity.

Fig. 1—Low Tension "Make and Break" Ignition.

The electricity does not jump across the space at the point of a spark plug in this system, the pressure or voltage of electricity is too low. The spark is made by breaking the two ends of the wires suddenly—a device called a "Make and Break Igniter," operated by a plunger rod does this. Read description in this instruction under "Low Tension" Ignition.

The type of coil used with this system is a low tension, single wound coil.

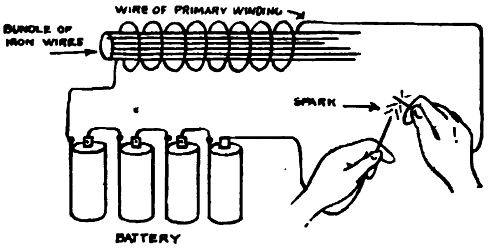


Fig. 2—Explanation of a Primary Coil (Single Wound).

By snapping the ends of the copper wires connected with a battery (after winding this wire around a bundle of iron wires) a spark will be produced. The wires must be "snapped" or separated suddenly, and the current must pass through the single wound or primary coil.

Wires simply connected to a dry cell will not produce a spark.

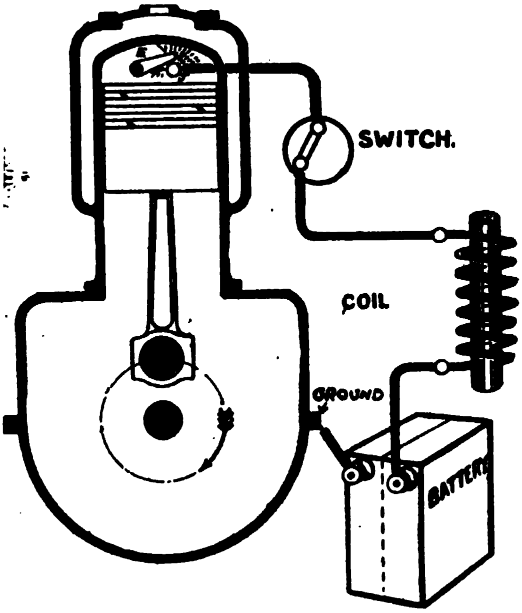


Fig. 3—"Make and Break" system of Ignition with Battery and Primary Coil. The Breaker E, snaps the wires as shown in Fig. 2.

CHART No. 66.

one to the battery and the other to the magneto, and the flat piece of brass is connected to the ignition circuit.

Thus When the Free End of the Switch is Swung to One Side, or the other, it rests on one of the knobs, and the corresponding battery or magneto is thrown in circuit, and furnishes the current for the ignition.

When the Switch is Between the Knobs, it is out of contact, and the circuit is broken.

Thus a Switch Serves Not Only to Connect Either of the Two Sources of Current, but also to break the circuit, which, of course, stops the engine.

The Switch Lever Can Be Detached from some makes of switches; when it is withdrawn, it breaks the circuit regardless of which side the switch is on.

Thus only the holder of the lever may run the car.

IGNITION SYSTEMS.

There are Two Systems of Ignition used for automobile engines; the MAKE AND BREAK, or LOW TENSION SYSTEM and the JUMP SPARK, or HIGH TENSION SYSTEM; the source of electric supply being either by dry cells, storage battery or a magneto. (The magneto is explained further on.)

The Word Tension Means Pressure or Voltage; high tension being high voltage, and low tension low voltage.

The Low Tension System of Ignition is used on only a few makes of automobiles. The Low Tension system was formerly used to a great extent on boat engines and is still used to a great extent on stationary engines.

The High Tension System of Ignition is the approved system now in use in very near all makes of motor cars. The High Tension System may be either by a High Tension Coil and a Battery or by a High Tension Magneto alone.

In this Instruction on Ignition We Will Deal Only with Coil Ignition, both Low Tension and High Tension. Magnetos will be treated further on.

LOW TENSION SYSTEM.

If the Ends of the Wires Connected With a Battery or mechanical generator are connected together, the current will flow, and if then the ends are separated suddenly a spark will be formed between them. (See Fig. 2, Chart 66.)

The More Powerful the Current, the larger will be the spark.

In the Make and Break Ignition System, two metal points are set in the combustion space of the cylinder, one of them being stationary, and the other movable, so that it may touch the other or be separated from it.

The Two Points are Connected in the Ignition Circuit, so that when they touch the current passes from one to the other, and when they are separated a spark is formed between them. (See Fig. 1, Chart 66.)

The Two Points are Called Electrodes, and form the IGNITER.

The Movable Electrode is Operated By a Cam, exactly as the exhaust valve of the engine is operated.

As the Spark is Needed Only Once During Two Revolutions of the Crank Shaft, the cam is attached to the half-time shaft, and operates the electrode by a rod called a tappet.

The Stationary Electrode is Insulated from the cylinder, and one wire of the circuit is connected to it.

The Movable Electrode Is Operated By a Cam, exactly as the exopening in the cylinder, and being thus in contact with it the current from the grounded wire of the battery can pass to it by the metal of the cylinder.

When the Two Points Are in Contact, the current flows from the positive pole of the battery by a wire to the stationary electrode, then to the movable, because the two are in contact, and back to the battery by the ground.

When the Two Electrodes are Separated by the Cam Acting on the Movable One, the circuit is broken, and a spark formed between them.

Chart No. 66, Fig. 1, Shows This Ignition System, it shows two sets of batteries connected to the switch in such a manner that either set may be used.

While Any Battery Would Give a Spark, a strong one is needed to ignite the charge suddenly and completely, and to do this it is necessary to use a strong current.

While a Current of Any Strength May Be Obtained by using sufficient cells in the battery, the limited space in an automobile will not permit more than a few to be used and therefore other means of strengthening the current are used.

A LOW TENSION COIL.

The Current is Strengthened, or INTENSIFIED, by the use of a SIMPLE COIL, sometimes called a PRIMARY COIL.

A Simple Coil Consists of a Bundle of Soft Iron Wires, called the CORE, around which is wound several layers of well-insulated copper wire. (See Coil in Fig. 1, Chart 66.)

A Current of Electricity Passing Through the Wire will make the core a magnet, the magnetism ceasing as soon as the current stops flowing.

The Magnetism of the Core Acts on the Current of Electricity, and intensifies it, and making it strong enough to produce a good spark between the electrodes.

The Reason for the Current Being Intensified requires an understanding of electrical engineering to make it clear; it is sufficient for the automobilist to understand that the current IS intensified.

The Positive Wire of the Battery leads to one terminal of the wire wound around the core of the coil, and the other terminal of the coil winding is connected to the stationary electrode.

Because the Action of the Cam Moves the Movable Electrode, it can be seen that making the cam operate sooner or later will make the spark occur sooner or later. (See Fig. 1, Chart 66.)

The Cam is Therefore Arranged so that it may act sooner or later on the tappet and electrode, and is controlled by a lever of the steering column, so that it can be advanced or retarded just as a timer on a high tension coil system.

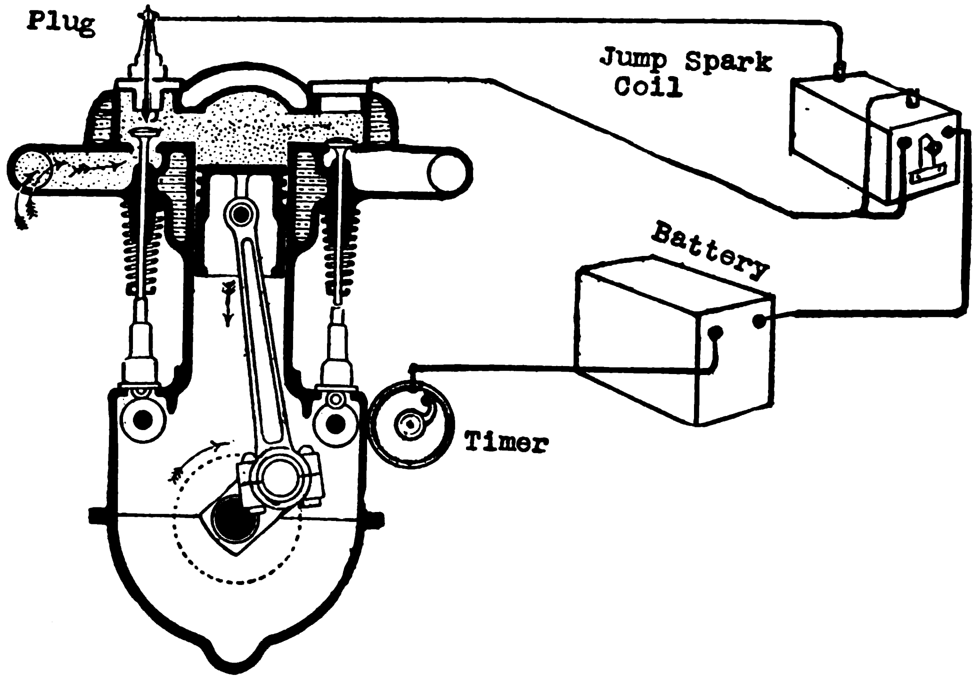


Fig. 1—General Wiring Plan of a Jump Spark or High Tension Coil system of Ignition. (The coil is double wound).

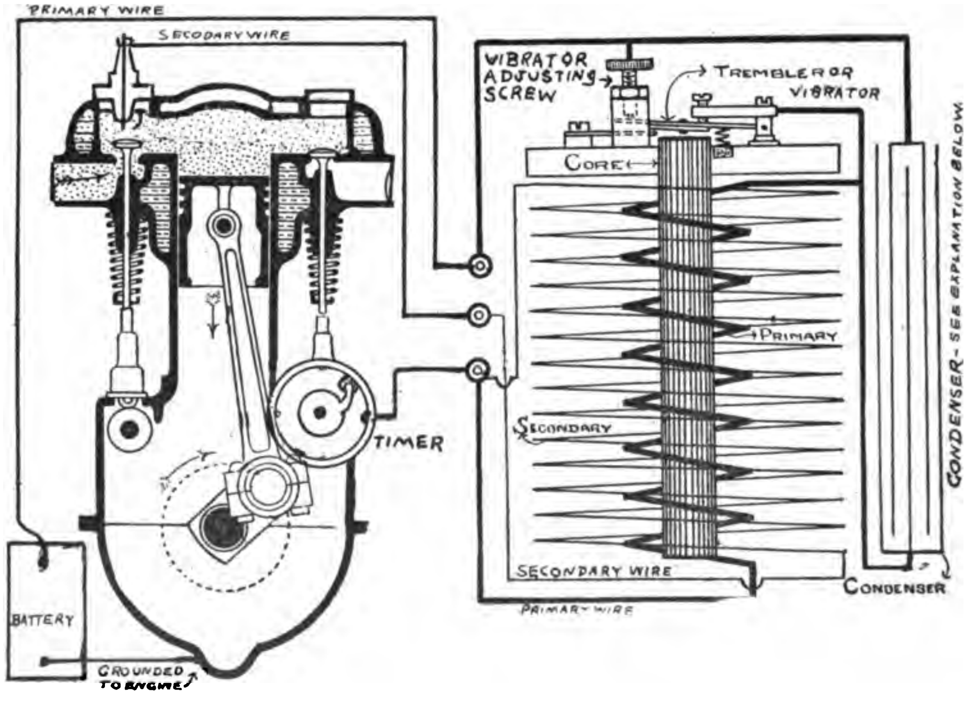


Fig. 2—Explaining the two Windings on a High Tension Coil and connections to the Magnetic Vibrator and the connection to the Condenser. Trace the wiring with pencil.

The Condenser consists of a series of sheets of tinfoil and paper interleaved. It absorbs the induced current in the primary when the circuit is interrupted. It assists in the rapid demagnetisation of the iron core, and prevents undue sparking at the platinum contacts.

Diagrams of High Tension Coil Ignition.

CHART No. 68.

INSTRUCTION No. 14.

HIGH TENSION COIL IGNITION—Jump Spark Ignition. Timing Devices or Commutators. Controlling the Speed. Spark Plugs. Testing the Ignition. Ignition Circuits. Adjusting Vibrators. Master Vibrators. Synchronous System of Ignition. Wiring Diagrams.

JUMP SPARK IGNITION.

The Low Tension, or make and break, system of ignition, described in the last lesson, is not used very much, the HIGH TENSION, or JUMP SPARK, system, is in general use.

Its Action (Jump Spark)—Depends on the Current being of such high pressure that it will jump across a space between two points, forming a spark as it passes.

The Current Produced by a Battery or even intensified circuit used for the make and break system, would not have enough **pressure to** jump across an open space, and must be intensified (or pressure increased) still more.

Where Simple Coils are Used for the make and break system, coils of another kind, called INDUCTION COILS, are used to intensify the current sufficiently to force it to jump across the open space. Therefore it is called the "Jump Spark" or "High Tension" (Meaning High Pressure).

JUMP SPARK OR HIGH TENSION COIL

An Induction Coil or Jump Spark Coil, consists of a core of soft iron wire, over which is wound a few layers of insulated copper wire, which is called the PRIMARY WINDING. (Chart 68 and 69.)

Over the Primary Winding is wound a great number of layers of exceedingly fine copper wire, insulated, called the SECONDARY WINDING.

When a Current of Electricity flowing through the primary winding is stopped and then started again, another current at great pressure flows in the secondary winding, ALTHOUGH THE TWO WINDINGS ARE NOT CONNECTED IN ANY WAY.

The Current in the Secondary Winding, called the SECONDARY CURRENT, flows in waves, there being a wave of current whenever the primary or battery current is stopped and started again.

The Reason for This Separate Current flowing in the secondary winding can only be understood after studying electrical engineering and it is not necessary to explain it here; the student, however, must understand that such a current DOES flow, although the primary and secondary windings are not connected.

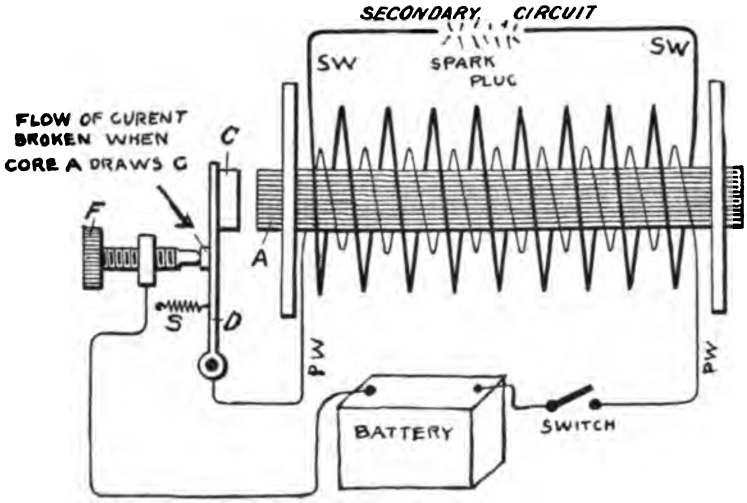


Fig. 1—Another sectional view of a Jump Spark Coil, also called an induction coil, high tension coil or secondary coil, showing the primary and secondary winding on the core and the magnetic vibrator, also illustrating the flow of electricity from battery through the primary wire circuit. When the current flows from battery through this primary wire wrapped around the core or bundle of iron wires A, (trace with pencil) the bundle of iron wires become magnetized and draw the vibrator C away from its connection with screw F.

The moment this vibrator is drawn away from screw F the circuit is broken and the bundle of wires A loses its magnetism, therefore the vibrator C is drawn back to screw F again by spring S, but the moment the contact is made again, A again becomes magnetized and again draws the vibrator C. This is repeated so fast the vibrator C simply buzzes. SW is a secondary wire wrapped around the primary wire.

When this vibration takes place the current is induced into the secondary wires by "induction" and this induced current is intensified, that is, the pressure is raised to such a high voltage it will jump the space at the point of the spark plug.

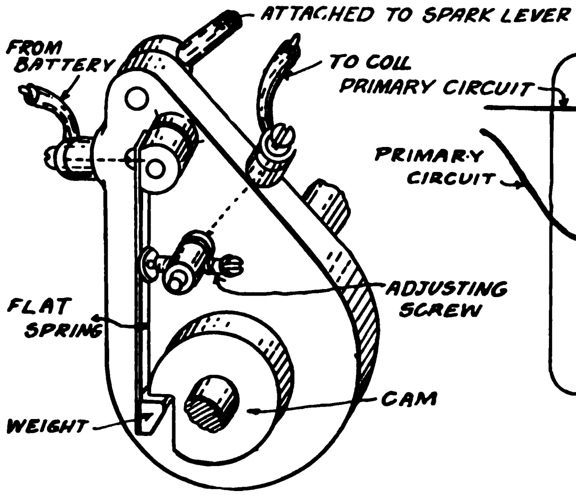


Fig. 2—A Mechanical Vibrator.
(Now Seldom Used.)

The purpose of this device is to open and close the primary electric circuit in rapid succession mechanically, instead of the vibrator.

When this type of timer is used the vibrator on coil is not necessary as shown in fig. 3.

The base is made of fibre or metal but the spring and screw are insulated from each other.

The above timer is used principally on single cylinder motorcycle engines.

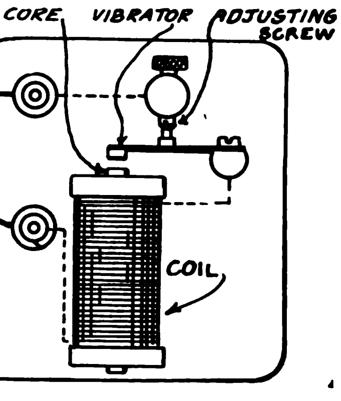


Fig. 3—A Magnetic Vibrator.

This illustration shows a vibrator placed on the coil, and operated electrically.

There must now be a "commutator or timing device," to close and open the circuit at the proper time in order to operate this vibrator electrically. (See timer on fig. 5, chart 70.)

CHART No. 69.

The Secondary Current acts in the same manner as the primary current; that is, it flows through wires and can be made to do work, and it can be grounded, the current leaving the secondary winding at one terminal and returning to the other.

The Difference is that it has exceedingly high pressure, and little volume, while the primary current has low pressure and greater volume.

As the secondary current only flows when the primary current begins to flow or stops flowing, there must be an arrangement that completes the primary circuit so that the battery current flows through the primary winding, and then breaks the circuit so that the battery current stops flowing.

THE MECHANICAL VIBRATOR.

This Arrangement is Called a VIBRATOR, and it may operate in two different ways.

One Way, which is going somewhat out of use, is called a Mechanical VIBRATOR, and is shown on Chart No. 69, Fig. 2.

It Consists of a Flat Spring with a small weight on one end, and the other end attached to a post.

The Weight Rests on the rim of a small wheel with a notch in it, so that when the wheel turns the weight drops into the notch.

One Wire from the primary circuit is attached to the flat spring and the other wire of the primary to an ADJUSTING SCREW.

When the Weight called the BOB, is in the notch of the wheel, or cam. the flat spring makes contact with the adjusting screw, and the current flows, but the wheel in continuing to turn moves the weight out of the notch, which separates the flat spring from the screw, and breaks the circuit.

Because of the Springiness of the Flat Spring, it vibrates when the weight drops into the notch, making and breaking the current.

By Making and Breaking the Contact in this way, the primary current flows through the primary winding in waves, flowing and stopping each time that the vibrator makes and breaks the circuit, which produces a corresponding current in the secondary winding.

THE MAGNETIC VIBRATOR.

The Magnetic Vibrator depends on the magnetism produced in the core of the coil when the primary current passes. (See Chart 69 Fig. 1 and 3.)

A Flat Spring, called the VIBRATOR SPRING, or BLADE, is so placed that one end of it is opposite the end of the core, the other end being firmly supported.

Touching the Vibrator Spring Near Its Free End is the point of an ADJUSTING SCREW.

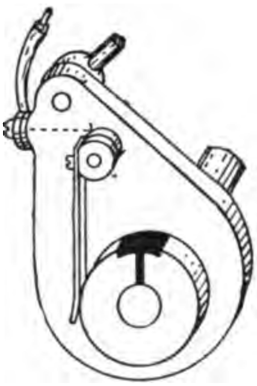


Fig. 1—A simple form of Brush Timer for a single Cylinder Engine.

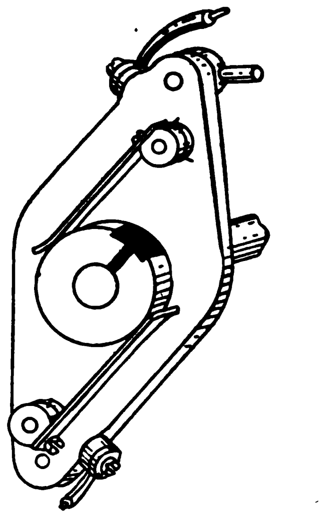


Fig. 2—A simple form of Brush Timer for a two Cylinder Engine.

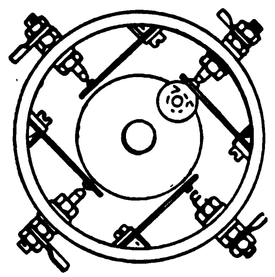


Fig. 3—A Four Cylinder Timer. A type not much used. Simular to fig. 2 Chart 69.

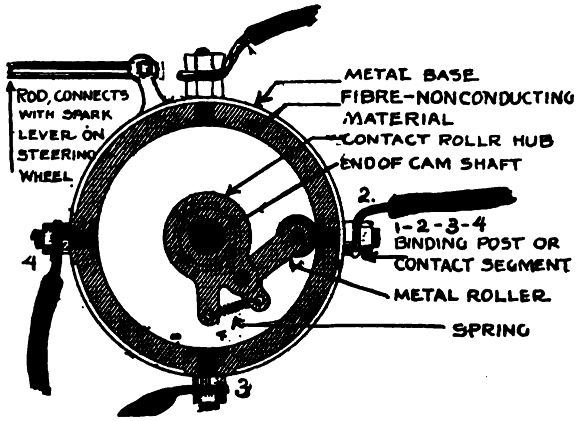

ROD, CONNECTS WITH SPARK LEVER ON STEERING WHEEL
METAL BASE
FIBRE-NONCONDUCTING MATERIAL
CONTACT ROLLR HUB
END OF CAM SHAFT
2.
1-2-3-4 BINDING POST OR CONTACT SEGMENT
METAL ROLLER
SPRING
4
3

Fig. 5—A Modern Type of Four Cylinder Timer. This type is also used as a one, two, three, four, six or eight cylinder timer by changing the contact segments.

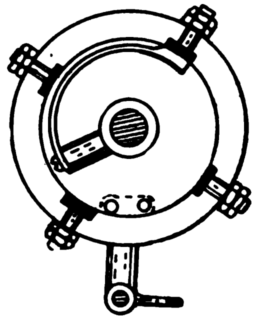


Fig. 4—Another Type of Four Cylinder Timer.

The type of Timer shown in fig's. 1, 2, 3 and 4 are not now in use. They are the old style Timers.

The type shown in fig. 5 is the now accepted and popular type. On this Timer the reader will note that there are four contact segments, therefore this Timer is intended for a four cylinder engine. This type of Timer is made for 1, 2, 3, 4, 6 or 8 cylinder engine by having more or less no segments. B is made of an insulated material, whereas the segments are made of metal. The roller is of metal and is grounded to engine. (See how the current travels in Fig. 2 Chart 71.)

CHART No. 70.

One Terminal of the Battery is attached to the adjusting screw; the vibrator spring is connected to one end of the primary winding of the coil; the other end of the primary winding is connected to the timer.

When the Timer Switches the current through the primary winding, the core becomes a magnet and attracts the free end of the vibrator spring, drawing it away from the adjusting screw.

As Soon as the Attraction Draws the Vibrator Spring Out of Contact with the adjusting screw ,the circuit is broken; the current stops flowing in the primary coil ,the core ceases to be a magnet, and the vibrator spring being no longer attracted by the magnetism, it springs back and again makes contact with the adjusting screw.

This Again Closes the Circuit, the vibrator spring is again attracted by the magnetism—thus the circuit through the vibrator spring and adjusting screw is broken and made again as long as the timer keeps the primary circuit closed through its contents.

The Strength of the Secondary Current, and consequently the strength of the spark, depends on the correct adjustment of the vibrator spring by the adjusting screw.

As the Construction of a Coil is Very Delicate, it is not expected of the driver to know more than how to adjust the vibrator. For any coil trouble, THE COIL SHOULD BE RETURNED TO THE MAKER.

..TIMERS.

Because the Secondary Current is Only Needed when it is time for the spark to pass and ignite the mixture, the primary current is switched into the primary winding only once during two revolutions, and the switching is done by a TIMER, or COMMUTATOR.

A Timer is a Revolving Switch that brings two pieces of metal, connected in the primary circuit, into contact with each other as it revolves.

One Part of the Timer is Stationary, and the other movable, being attached to the half-time shaft.

The Usual Location For a Timer in an engine is on the end of the cam shaft, as shown in Chart 71, Fig. 2, or Chart 71A, Fig. 2.

Timers are Made in Various Forms, some of which are shown on Chart 70

The Simplest, being one shown in Fig. 1, Chart 70, consisting of a small wheel of hard rubber, wood fibre, or other insulator, in which is set a piece of metal that makes contact with the shaft to which the wheel is attached.

A Flat Metal Spring, called a BRUSH, rests on|the edge of the wheel, and as the wheel turns, the metal plate is brought in contact with it.

One Wire From the Primary Circuit is Connected to the Brush; the shaft, being of metal, and resting in metal bearings, is in contact with the metal of the engine, and consequently the electric current may pass from it to the primary wire that is grounded on the engine.

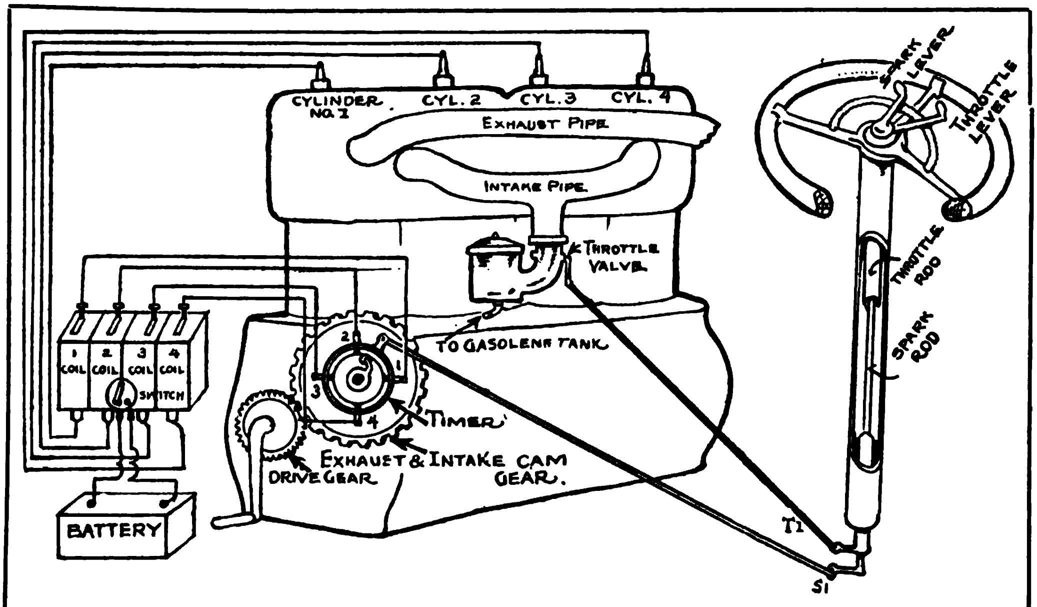


Fig. 1—A Simple Drawing Explaining the General Ignition Parts of a Four Cylinder Engine and the Spark and Throttle Control.

Above illustration explains a four cylinder engine with a four cylinder coil and a storage battery.

See matter on page 184 and Chart 56.— "How the Timer Helps control the speed."

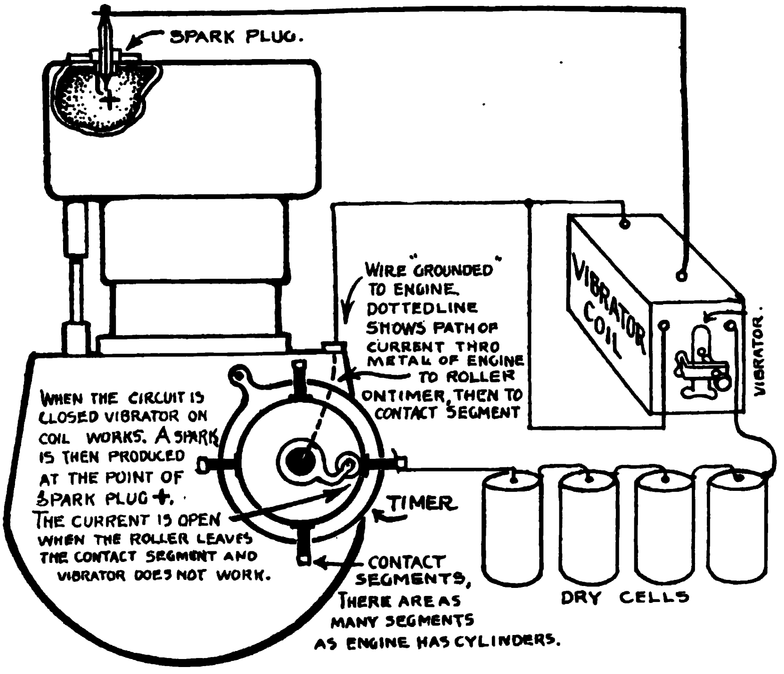

SPARK PLUG.
WIRE "GROUNDED" TO ENGINE. DOTTED LINE SHOWS PATH OF CURRENT THRO METAL OF ENGINE TO ROLLER ON TIMER, THEN TO CONTACT SEGMENT
VIBRATOR COIL
VIBRATOR.
WHEN THE CIRCUIT IS CLOSED VIBRATOR ON COIL WORKS. A SPARK IS THEN PRODUCED AT THE POINT OF SPARK PLUG +.
THE CURRENT IS OPEN WHEN THE ROLLER LEAVES THE CONTACT SEGMENT AND VIBRATOR DOES NOT WORK.
TIMER
CONTACT SEGMENTS, THERE ARE AS MANY SEGMENTS AS ENGINE HAS CYLINDERS.
DRY CELLS

Fig. 2—Timing Devices are Placed Usually on the Shaft on which the valve cams are placed or the half time gears.

The Commutator or Timer is Used to Complete the Electric Circuit at a certain time. It is important that the connection be made just at the proper time. When the spark lever on the steering wheel is "advanced" or "retarded" it connects with this timing device and advances it or retards it—that is, it causes contact to be made early or late. This connection from spark lever is made as shown on lever on top of timer.

CHART No. 71.

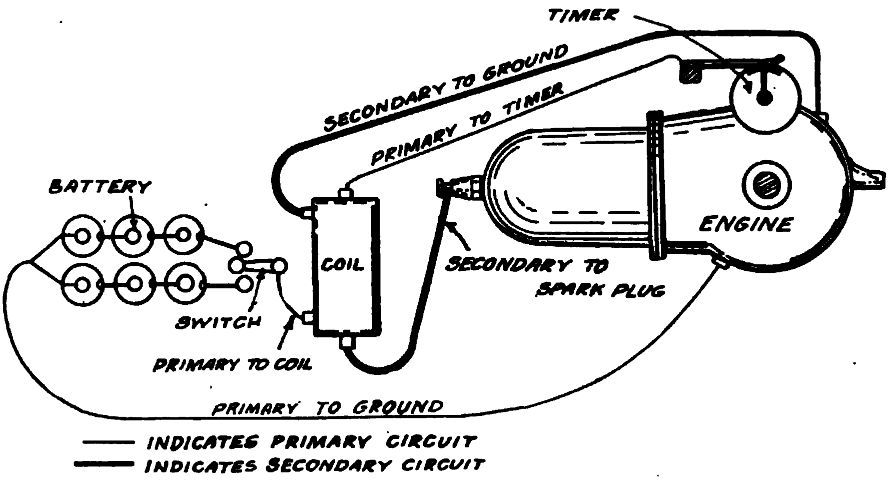


Fig. 1—Timing Device and its Connections on a Single Cylinder Horizontal Engine with a High Tension Ignition (Using Two Sets of Dry Cells.)

A Timing Device is usually placed on one end of the cam shaft that the half time gears are on. Its duty is to complete the circuit at a certain time and thereby cause the vibrator on the coil to vibrate, this causes the spark to occur at the plug point. (Plug is screwed into cylinder.)

Illustration shows a complete system for a single cylinder engine using two sets of batteries—one set is used for a period then the other—this keeps them from running down rapidly – a dry cell will recuperate. Note the double switch.

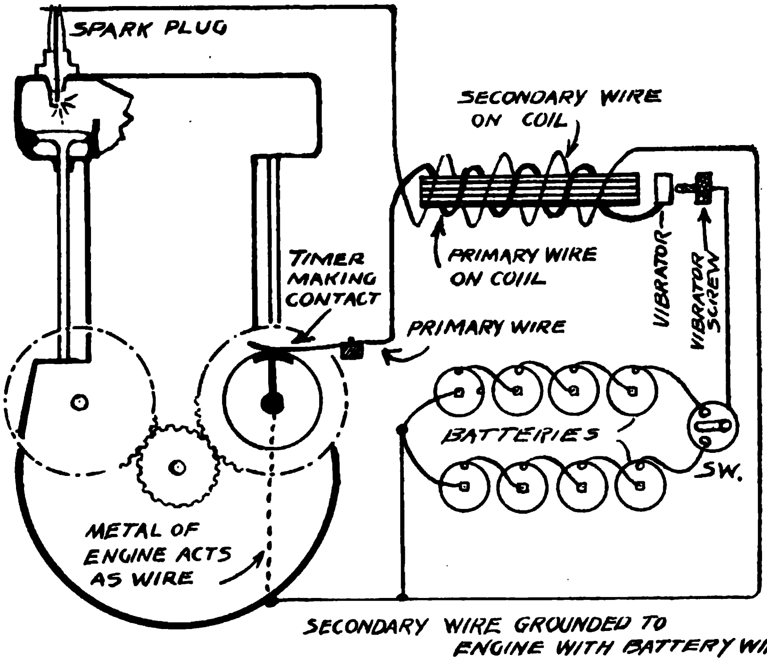


Fig. 2—A Timing Device and Jump Spark Coil Circuit with Two Sets of Dry Cells on a Vertical Cylinder Engine.

Purpose of this illustration is to show how the timer is placed on the end of cam shaft and how the spring or brush (usually in form of a segment, (see timer in Chart 70) makes contact and how the current flows through the coil.

CHART No. 71A.

Thus When the Wheel Has Turned so That the Piece of Metal, called a CONTACT, makes connection with the brush, (the brush being insulated from the base), the current passes from the brush to the contact, to the shaft, and then through the metal of the engine back to the battery.

As the Wheel, in continuing to turn, moves the contact away from the brush, the circuit is broken, and the current stops.

Each Time That the Contact Touches the Brush the battery current passes through the primary winding of the coil, making the vibrator operate, and causing the secondary current to form its spark in the cylinder.

When an Engine Has More Than One Cylinder, there is a contact on the timer for each.

A Two Cylinder Timer, and several types of four cylinder timers are shown on Chart 70.

TWO CYLINDER TIMER.

The Two Cylinder Timer is Similar to the One Cylinder Timer already described, except that it has one more brush; a wire leads from each brush to one of the coils, so that as the timer revolves it makes contact first with one brush and then the other, a spark passing in the corresponding cylinder as each contact is made.

FOUR CYLINDER TIMER.

In the First Type of Four Cylinder Timer Shown (Fig 3) the revolving part in the center does not make contact itself, but the small roller that it carries presses together two contacts, one being on a flat spring so that when the roller has passed away from it, it springs away from the stationary contact, breaking the circuit.

One Wire is Attached to the Stationary Contact and the flat spring is grounded.

In the Second Type of Four Cylinder Timers (Fig. 4), a curved spring is dragged around the inside of a ring, in which are set the four contacts.

A Wire For Each Coil is attached to the corresponding contact, the curved spring being grounded through the half-time shaft to which it is attached.

In the Third or Modern Type (Fig. 5), a roller attached to the cam shaft revolves inside of an insulated ring, making contact with the terminals, 1, 2, 3, and 4.

HOW THE TIMER HELPS CONTROL THE SPEED.

The Timer is Connected With the Spark Lever on the steering wheel. (See Fig. 1, Chart 71.)

When the Spark Lever is Pushed Forward the timer is shifted forward so that the metal roller makes contact earlier with the contact segment.

This is Called "Advancing" the spark.

If the Timer is Shifted Back instead of forward the contact is made later.

This is Called "Retarding" the spark.

When the Engine Leaves the Factory the Timer is Set so that the contact is made just as the piston is over center, or when the throw of the cam shaft is over top center of the compression stroke.

The Spark Lever is Placed in the Center of the Quadrant when the above contact is made.

The Setting of the Contact in this manner then permits the shifting of the lever either to "Advance" or "Retard."

THE GAS THROTTLE LEVER.

The Gasoline Throttle Lever is the lever used to run on and is the lever used to increase or decrease the speed of an engine.

This is Done by Opening and Closing the Throttle, as explained under the subject of Carburetors.

The Spark Lever Must Work With the Gasoline Throttle.

If the Speed of the Engine is Increased by opening the throttle it is also necessary to advance the spark lever along with the **throttle** lever, because as the speed increases the spark must occur earlier.

If the Speed of the Engine is Decreased by closing the throttle then the spark lever must be "retarded."

It is Well to Run With the Spark Lever as Well Forward, or Advanced as Possible, as it will tend to keep the speed of the motor up and consume less gasoline and create less heat.

If the Spark Lever is Too Far Advanced, then the engine will pound or knock because the ignition will take place before the piston is over the center.

The Amount of Advancing and Retard of the spark must be learned by actual practice in order to get the best results; motors vary slightly in this respect.

SPARK PLUGS.

The Spark Plug is Screwed Into the Cylinder so that it projects into the combustion space, and carries the two points between which the spark is formed.

While There are Many Different Designs, the one on Chart 72, Fig. 2, shows the general construction.

It Consistes of a Sleeve, with a screw thread cut on it, so that it may be screwed into the cylinder, and the sleeve has a curved wire projecting from it.

Inside the Sleeve is a Tube of Insulating Material, usually porcelain or mica, which will stand the heat of the explosions.

Through the Tube Passes a Rod, the inside point of which is about 1-32 of an inch from the wire attached to the sleeve.

To the outer end of the rod is attached the secondary wire from the coil.

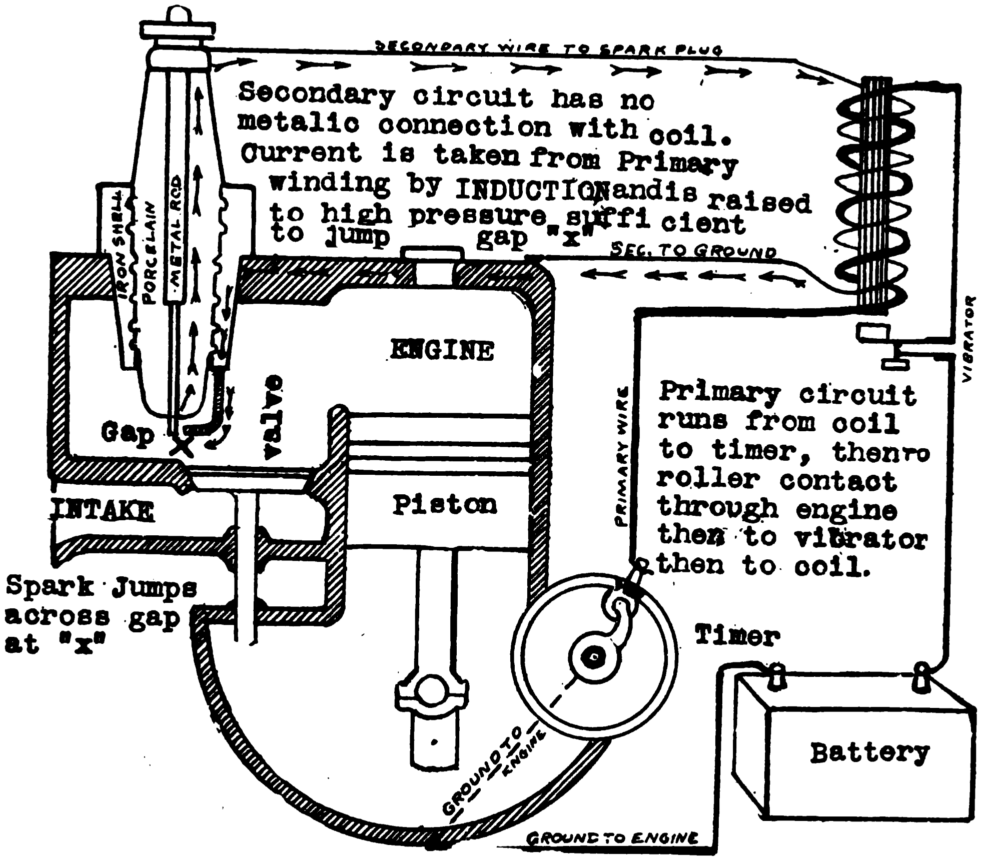

SECONDARY WIRE TO SPARK PLUG
Secondary circuit has no metalic connection with coil. Current is taken from Primary winding by INDUCTION and is raised to high pressure suffi cient to jump gap "x"
IRON SHELL
PORCELAIN
METAL ROD
Gap
X
valve
ENGINE
SEC. TO GROUND
VIBRATOR
PRIMARY WIRE
Primary circuit runs from coil to timer, thenro roller contact through engine then to vibrator then to coil.
INTAKE
Piston
Spark Jumps across gap at "x"
Timer
Battery
GROUND TO ENGINE
GROUND TO ENGINE

Fig. 1—An exaggerated drawing, made for the purpose of illustration how the spark plug is screwed into the combustion chamber of the Engine, and how the current is carried from the battery through the primary winding of the coil, to timer, etc. Trace the circuit with your pencil.

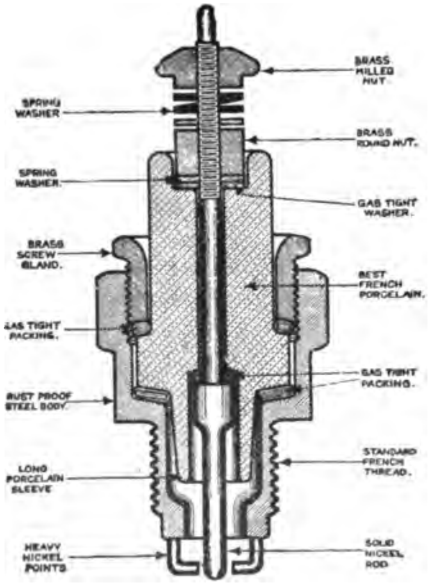


Fig. 2—Names of parts of a Plug especially made for Magneto use. Note the heavy double terminals. Magnetos give a heavy "Fat" spark.

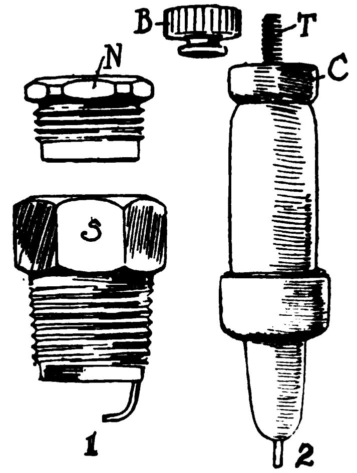


Fig. 3—Parts of a Spark Plug Separate. A type of Plug usually used with a Jump Spark coil system of ignition.

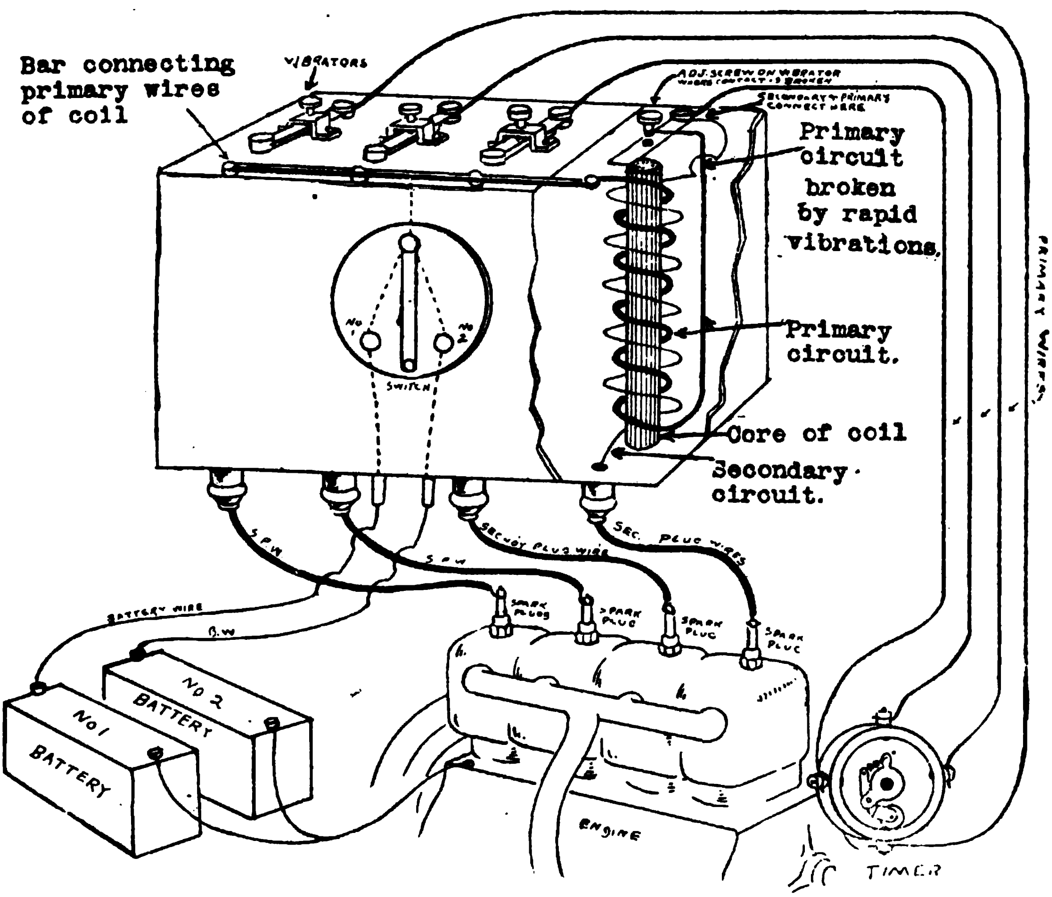
S—Is the iron shell which screws into the Engine cylinder.

N—Is the brass bushing which holds the porcelain C in the iron shell.

C—Is the porcelain with rod T running through it.

B—Is the lock nut or thumb nut which holds the secondary wire. B screws on the end of T to hold wire in place.

CHART No. 72.



Wire Connections of a Four Cylinder Jump Spark Coil System.

(Follow the circuit with your pencil.)

The Above Illustrates the entire system of coil ignition.

We Will Begin With the Storage Battery; there are two batteries but only one used at the time. If one runs down, the other one is thrown into service by switch on the coil The switch is now open, but if the switch is thrown on No. 2 contact the circuit would be from No. 2 battery to switch, through switch lever to bus bar on front of the coil, which connects the primary wires which are wrapped around a core or bundle of soft iron wires.

The Other End of This Primary Wire connects with a magnetic breaker or screw on vibrator; the current is broken here until contact is made on one of the points of the timer. The timer revolves as explained previously.

When This Contact Is Completed the primary circuit is closed on one of the four coils. When this circuit is closed, the bundle of iron wire becomes magnetic and draws the vibrator down, but the moment it is drawn away from the contact with the screw, the circuit is broken and it springs back and makes contact again and is immediately drawn down again, this of course is quick and rapid. This is vibration, is kept up as long as the contact is made on the timer which of course is only for a moment, but during that time the vibrator makes several vibrations or "buzzes."

When These Vibrations Occur, the current is induced into a wnidinw of wire wrapped around the primary winding, called a secondary winding or circuit.

This Secondary Winding of course has two ends; one end goes to a spark plug and the other end connects to one side of the primary wire which grounds it through the timer back to engine then to plug again.

One of the Coils Is Connected to One Cylinder and the duty of the timer is to make contact at a certain time in order that the right coil will operate and supply an electric spark to the right cylinder at the right time. Put your pencil on the primary wire and follow its circuit, then put your pencil on the secondary wire and follow its circuit. Start at the switch.

CHART No. 73.

Because the Sleeve Bearing One of the Points is Screwed Into the Cylinder, the electrical current may flow through the metal of the engine to the place where the other secondary wire is grounded, so that when the current flows from the coil to the rod through the spark plug it jumps the space between the two points, and returns to the coil by the grounded wire.

CIRCUIT.

The Manner in Which the Parts of the Ignition Circuit are Connected together is shown on Chart 72, Fig. 1.

From the Battery is Led a Ground Wire, attached to any convenient part of the engine.

When the Timer on Engine Revolves and Makes Contact the current flows from the battery through the vibrator and the primary winding of the coil, through the contacts of the timer, and by the metal of the engine and the ground wire back to the battery. (Fig. 1, Chart 72.)

As Soon as the Primary Current Causes the Vibrator of the Coil to Operate, the secondary current is formed, and goes to the spark plug, where it jumps the space between the points, at "X" and returns to the coil through the metal of the engine and the secondary ground wire.

The Most Usual Trouble in the operation of the jump spark system is the fouling of the spark plug by carbon from a mixture that is too rich in gasoline, or by the burning of lubricating oil.

This Carbon Deposit Short Circuits the Points; that is, it is easier for the current to go from one point to the other by running over the carbon, which is a conductor, than by jumping across the gap on the plug. (See Fig. 1, Chart 74.)

TESTING THE IGNITION.

When the Engine Stops, and it is suspected that the ignition system is at fault, it may be tested to locate the fault.

Crank the Engine Slowly, to see if the vibrators are working correctly.

If They Are, disconnect the wire from the spark plug, and with the timer making contact, hold the wire close to the spark plug terminal, when, if things are correct, a strong spark should pass.

A Further Test May Be Made by removing the plug from its position, and after connecting the wire to it, lay it on the metal of the engine so that only the metal shell touches. (See Chart 74, Fig. 1.)

The Spark Points and the connection should be clear of the metal, as otherwise there would be a short circuit.

Crank the Engine so that the timer makes the corresponding contact to that cylinder, when a strong spark should pass between the points.

The Space Between the Spark Points must be considered an insulator, and it must be remembered that the compressed charge in the cylinder through which the spark is required to jump is a better insulator than uncompressed air.

A Spark That Will Jump the point or gap of a spark plug when

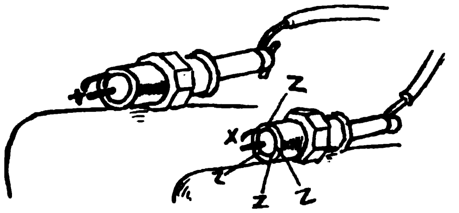


Fig. 1—To test your spark plug lay it on the cylinder. Crank Engine until coil buzzes. If plug sparks at "X" it is O. K. If at "Z" it is defective or "short circuited."

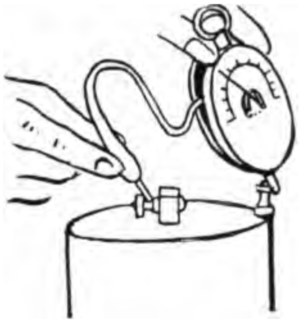


Fig. 2—Dry Cells 2½x6 will give fifteen or more amperes, and are generally safe for use as low as seven amperes. If a dry cell is larger it will give more amperage or quantity but the voltage or pressure remains the same.

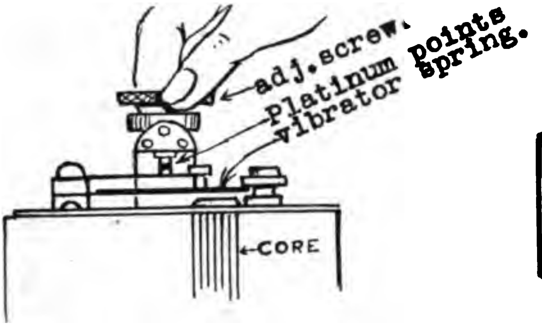


Fig. 3 —Adjusting a Vibrator on a Coil.

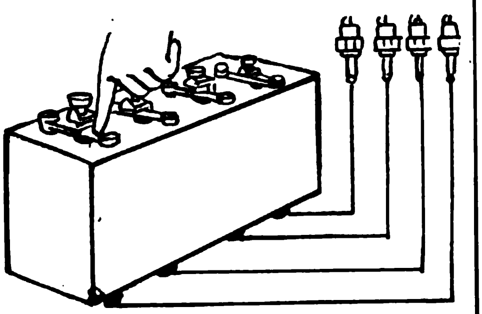


Fig. 4—To find which spark plug is missing; hold the vibrator springs down on the coil.

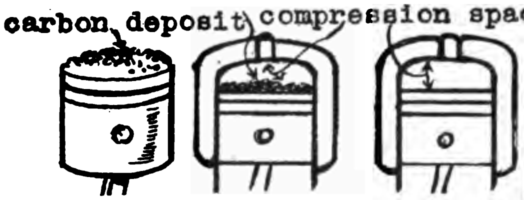


Fig. 5—Poor grade of oil will burn and leave carbon deposit (soot) on end of piston and thereby increase compression space and cause pounding. Will also cause "pre-mature" ignition.

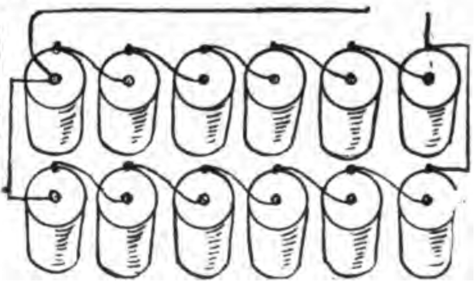


Fig. 6—Multiple connection of both sets of dry batteries for emergency.

CHART No. 74.

the plug is out of the cylinder may not have strength enough to jump when the plug is screwed in the cylinder and under compression. So the spark must be especially strong, and should be able to punch a hole through a visiting card held between the points.

If the Spark is Weak, the batteries may be exhausted, and they may be tested by an ammeter if dry cells, (Chart 74, Fig. 2.) or if a storage battery, instructions are given further on.

A Meter has two terminals, one is usually in the form of a point on the case, and the other a short piece of wire.

Placing One Point on the Positive Pole and the other on the negative, according to the directions of the manufacturer, the needle will show the amperage or quantity in a dry cell.

If the Batteries are Good, but there is no spark, the timer should be examined to be sure that it makes contact.

If the Timer is Correct, tighten all terminals, being sure that they make good contact.

A Further Cause of Trouble is the breaking of a wire inside of the insulation, where it cannot be seen.

Each Wire may be tested separately, or what is better, new wires should be substituted, one at a time, trying for a spark as the work proceeds.

In Addition to Broken Wires, broken or rubbed insulation should be looked for.

A Wire With the Insulation Rubbed Away so that the wire is exposed, will cause a short circuit whenever it touches metal.

ADJUSTING THE VIBRATOR ON THE COIL.

While Vibrators are Often Adjusted According to the Buzz that they make, the only positive method is the running of the engine.

The More the Adjusting Screw is Screwed Down, the shorter is the stroke that the blade can make, and consequently the more vibrations there will be to the second.

When the Engine Has But One Coil, the adjusting screw may be moved little by little while the engine is running, until the most powerful running is obtained, with the least possible spark at the contact points on the vibrator blades. (See Chart 74, Fig. 3.)

When a Spark Occurs Between These Points, it wears away the platinum of which they are made, and an excessive spark will heat them so that they may fuse together.

There Will Always Be a Small Spark, but the smaller it is the better for the contacts.

Sparking is Often Caused by rough contacts, and these may be smoothed by the use of a very fine flat file.

TO FIND A MISSING SPARK PLUG.

When an Engine Has More Than One Cylinder, it should be started running, and then all of the vibrator blades, but one, should be held down with the fingers so that they cannot operate, and the engine will be running on one cylinder. (See Chart 74, Fig. 4.)

The Free Vibrator should be adjusted until the one cylinder is running at its best, with the smallest spark at the vibrator contacts.

When This Vibrator is Adjusted Correctly, another should be released, and the rest held down, including the one adjusted.

By Thus Adjusting the Vibrators one at a time, each may be made to do its best, which will result in the successful running of the engine.

The Vibrators Will Not All Make the Same Sound, some being higher than the others, but this makes no difference to the running of the engine.

The Difference in Tone May Be Due to a Difference in the Steel of which vibrator blades are made or slight difference in the point at which the contact screw touches the blade.

The Important Thing to Secure is Regularity of the vibrations, and the absence of mis-contacts.

RUN DOWN DRY CELLS

When There Are Two Sets of Dry Cells and Both Sets Weak, connect them as shown in Fig. 6, Chart 74. This will often supply sufficient electric current to reach home, especially if the vibrator spring is weakened by loosening the tension by adjusting the screw.

CARBON DEPOSIT FOULS SPARK PLUG.

A Poor Grade of Oil Will Turn to Carbon (Soot) and will deposit on the end and inside of the spark plug and "short circuit" the plug so that the spark will not occur at the point of the spark plug.

Poor Oil Will Also Leave Carbon or soot deposit on the end of the piston and inside of the Combustion Chamber.

This Deposit Hardens and sharp points of it will project.

This Projection Will Become Heated white hot and will cause the gas to ignite before it is time and this is called premature or "Pre-ignition."

The Collection of This Carbon (Soot) Deposit Will Also Decrease the Space Between the Head of the Piston and the Head of the Cylinder and will increase the compression (pressure) to such an extent that it will cause the engine to pound.

A Good Grade of Oil is Essential for good ignition and will prevent a lot of ignition troubles. (See Lubrication.)

THE HIGH-TENSION DISTRIBUTOR OR SYNCHRONOUS SYSTEM OF IGNITION.

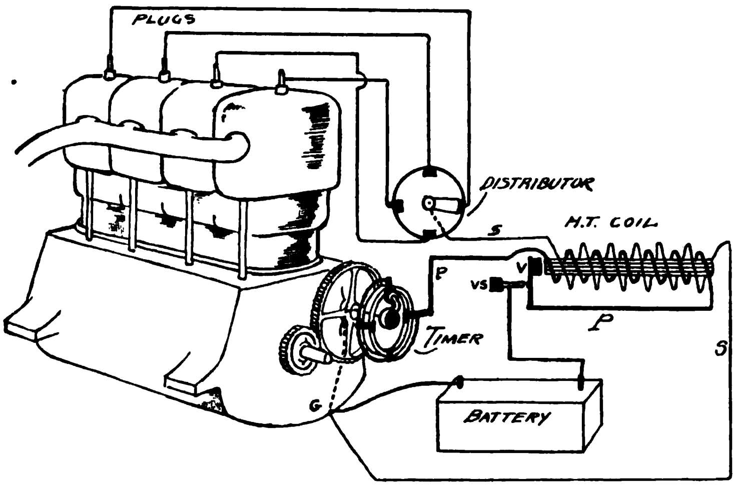
In the Foregoing Examples it will have been noted that the amount of wiring required for motors having more than one cylinder becomes increasingly complicated.

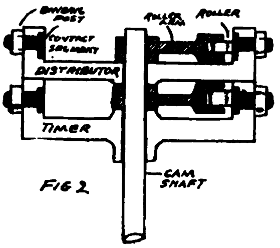
A System Now Generally Used, known as the distributor system, very considerably simplifies the wiring, and at the same time more accurate timing of firing of the respective cylinder is obtained. (See Fig. 1, Chart 75.)

One Tremble Coil is Necessary, this having the high-tension terminal joined up to the "distributor," which is a special form of rotating switch highly insulated, which directs the high-tension current to the cylinders in the required order.

The Distributor Rotates at the Same Speed as the Contact Maker, and in perfect unison with it; that is to say, when the low tension circuit is completed, the high tension circuit is completed likewise.

The Diagram Should Make the System Clear, it being borne in mind that the distributor is rotating as well as the contact maker and in perfect synchronism with it.





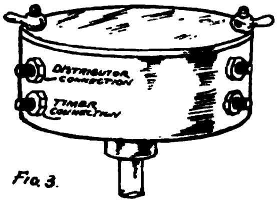


Fig. 1—A "Distributor or Synchronous System" of Ignition.

Fig. 2—A Sectional View of Timer and Distributor. Note that they are built together. The Timer takes care of the Primary Circuit and Vibrator, while the Distributor distributes the Secondary Current to the plugs.

Fig. 3—Showing Timer and Distributor in one case. This device is usually placed on end of the cam shaft.

A Distributor or synchronous system of Ignition is simply a combination of a Timer and a Distributor in one (see Fig. 3). A single High Tension Vibrator Coil is used for igniting a multiple of cylinders. The Timer opens and closes the Vibrator circuit (Primary P) in the usual manner.

The Distributor opens and closes at the same time, the secondary currents, and distributes it to the proper cylinder at the right time.

When there are several Vibrators, perhaps no two will act in exactly the same time. Consequently, in the ordinary multiple coil system, the closing of the primary circuits may occur at exactly corresponding moments for all of the cylinders, and the production of the spark of ignition will be more or less "out", owing to the variation in the "lag" of the different vibrators.

With a Distributor and Single Coil, the lag is the same for all the cylinders, hence the application of the word SYNCHRONOUS.

The wiring diagram above shows the connections of a Synchronous Distributor system; for clearness, the two windings of the coil are shown separated from each other and for the same reason also, the Timer and Distributor are separated, although they are usually made together.

A Distributor is built similar to a Timer. Note the segments on Timer on engine are all connected together.

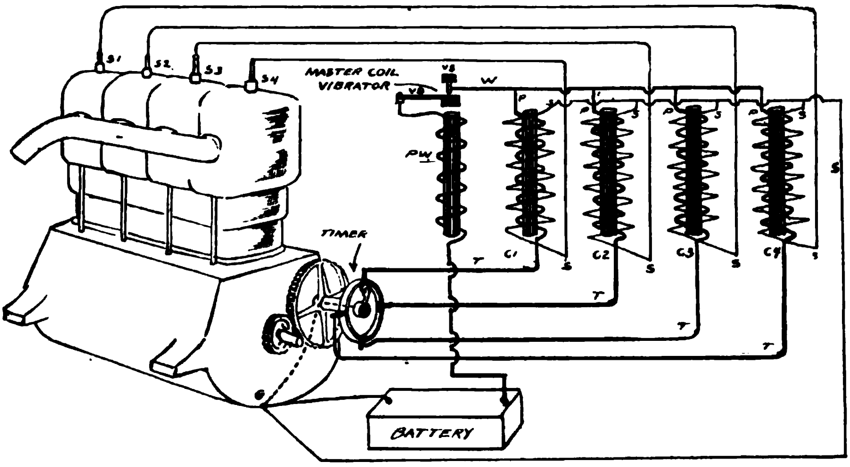


Fig. 4.—Ignition with a "Master Vibrator."

This System is also called a Synchronous System.

This illustration, Fig. 4, shows a **Master Vibrator Coil System.** This system uses but **one Vibrator for a multiple of Coils.**

Above illustration shows a four-cylinder engine and four coils. The master vibrator vibrates for all four.

One end of primary windings are all connected in parallel at the top by a wire—W. The lower ends of primary wires connect with the segments on the timer.

The secondary windings of the four coils connect with the four spark plugs at one end, all "ground" at the other end.

The vibrator coil has but one primary winding. This coil is merely connected in series with the four coils.

A Distributor System and a Master Vibrator System of Ignition.

CHARTNo. 75.

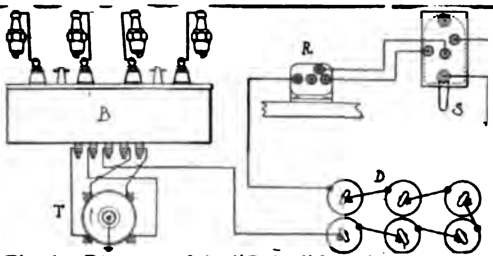


Fig. 1. Diagram of the "Delco" Ignition System.

The "Delco" System of Ignition.

This system is similar to the Master Vibrator System explained in Chart 75. The system shown is for a four cylinder engine.

Fig. 1. B—Coil Box containing four non-vibrating high tension coils. R—Relay or Master Vibrator, wired in the circuit of the timer. It does the vibrating for the four coils. S—Switch. T—Timer.

Fig. 2. C - Winding on the Controlling Relay (R). There are two windings on this coil; a primary and secondary.

The Electric Current, when the timer makes contacts, passes through the primary winding, this magnetizes the core and armature A is pulled down, separating the contact points P, and opening the circuit.

Six or eight Dry Cells are used in series. A storage battery may be used if desired.

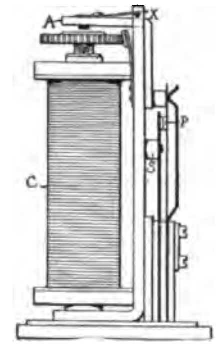


Fig 2. The Controlling Relay

THE ATWATER KENT IGNITION SYSTEM EXPLAINED.

The Atwater Kent System comprises two elements; a simple non-vibrating coil (C) with no moving parts and a special contact maker and distributor (A), which takes the place of the ordinary timer.

There are no vibrating contacts, the sparking being produced by mechanical means. This system produces a single, hot spark for each power impulse.

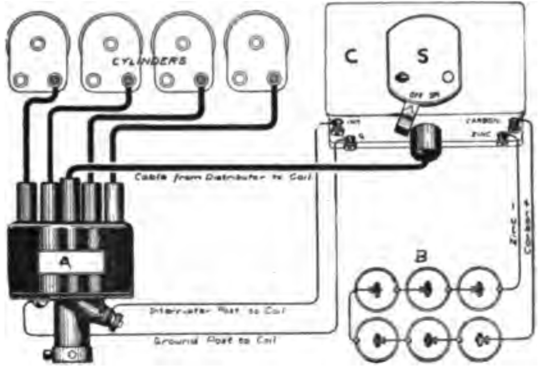


Fig. 4. Diagram of Connections of Atwater-Kent Ignition System.

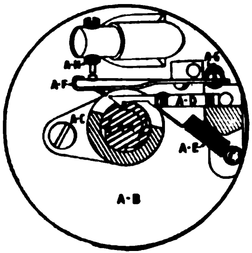


Fig. 1.

Figures 1, 2 and 3 show the mechanism and operation of the Contact Maker and Distributor which is called the "Uni-Sparker." The timer shaft A-A has notches cut for each cylinder. These notches engage the lifter A-D which is pulled out as far as the notch will hold it (see Fig. 2), and then is snapped back by the spring A-E. In returning to its original position, the lifter A-D strikes a projecting tongue on the contact arm A-F and causes a brief contact, as shown in Fig. 3. This closes the primary circuit momentarily, producing a single, heavy spark at each plug in succession. The contact takes place so quickly that it is not discernable to the eye.

Figure 4 shows the wiring of the Uni-Sparker.

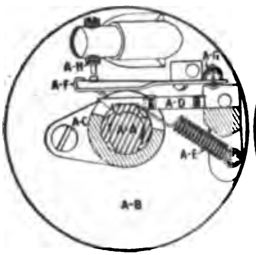


Fig. 2.

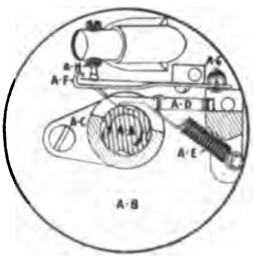


Fig. 3

CHART No. 75A.

A Secondary Distributor is Made in Combination With a Timer each with as many contacts as the engine has cylinders and with the moving parts of each attached to the same shaft and revolving. (See Chart No. 75, Figs. 1, 2 and 3.)

The Battery is Connected to the Single Coil in the usual manner, and a wire is run from the primary terminal of the coil to the timer, where it is connected to the four points.

Thus When the Timer Revolves, the current is passed through the one coil every time that contact is made.

If With This Arrangement a wire was run from the secondary terminal of the coil to the four spark plugs, sparks would pass in all four cylinders whenever the timer made contact.

Instead of This, one wire is run from the secondary terminal to the moving part of the distributor, and from each contact point of the distributor to the proper spark plug.

When the Timer Makes Contact, and the secondary current is formed, it flows to the distributor, which at that instant has made contact with one of the points, so that the secondary current flows across the contact and to the spark plug that is connected.

The Advantage of this system is that there is only one vibrator to keep in adjustment, and fewer parts.

The Disadvantage is that the coil has no rest, and the constant use tends to heat it, and destroy its insulation.

The Constant Action of the Vibrator is liable to burn the vibrator points, and destroy them.

IGNITION WITH A MASTER VIBRATOR.

In This System we have a multiple of coils, C1-C2-C-3 and C4. (See Fig. 4, Chart 75.)

These Coils Are Regular Double Wound High Tension Coils, with vibrators, all of which may be operated by a single or MASTER VIBRATOR.

The Master Vibrator has but a single winding and is connected in series with the double wound coils.

The Advantage of Such a System is that there is but one vibrator to keep in adjustment, since this vibrator serves for all the cylinders; whereas, with one for each unit, all have to be kept in adjustment and the difficulty of keeping several adjustments is a considerable factor.

THE POPULAR FORM OF IGNITION IS THE "DUAL" SYSTEM.

Quite a Number of Manufacturers are using two systems of ignition on one set of spark plugs; for instance, a High Tension Magneto and a Coil and Battery. A switch is used in conjunction with the system so that it can be switched from one to the other. This is called a "DUAL" System of Ignition. In fact any two systems of Ignition using one set of Spark Plugs is a "Dual" system. (See Charts 77, Fig. 1—Chart 79.)

A "Double System" of Ignition is used quite often on large touring cars and consists of two systems of ignition but with TWO sets of spark plugs.

The Above Systems Will Be Explained Fully under subject of Magnetos, further on.

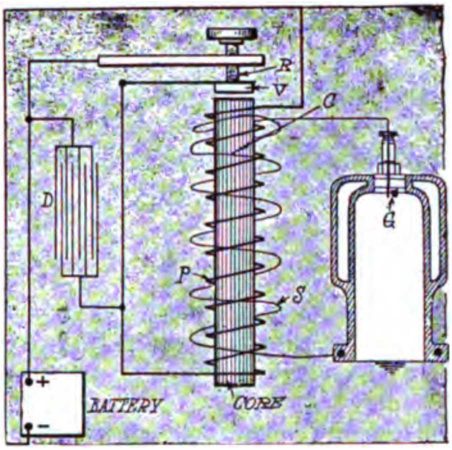
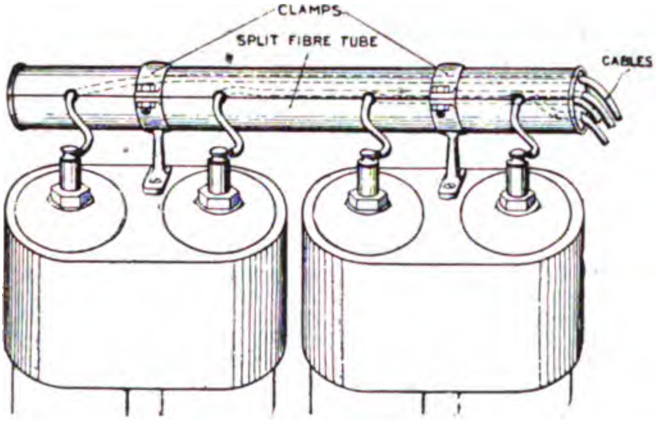


Fig. 10—How the Condenser is Wired in the System of a Jump Spark or High Tension Coil.

D—Condenser.
P—Primary Wire Circuit.
S—Secondary Wire Circuit.
G—Spark Plug.
V—Vibrator Spring.
R—Vibrator Adjusting Screw.

Explaination of a Condenser.

The Condenser of an ignition system is provided to increase the speed and efficiency of the impulses of the secondary current. When current stops flowing in the primary circuit, the core of the coil is demagnetized. The quicker the demagnetization, the quicker the impulse created in the secondary winding. Now, when the primary circuit is broken, if it were not for the condenser the primary current would tend to flow across the points of the vibrator until the distance between them became too great. This tendency would cause excessive sparking and burning of the points, and reduce the efficiency of the secondary impulse. The condenser absorbs the current which flows for an instant after he points are separated, and gives it off again when the points are again in contact.

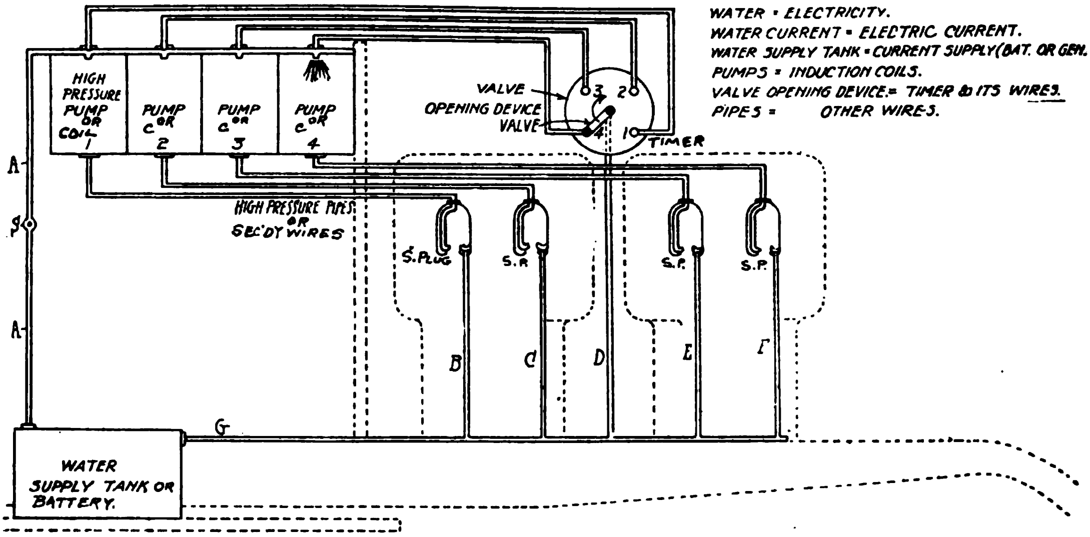


Protect the Plug Wires.

Owing to the fact that the current running from the coil to the plugs (secondary wires) is of high tension, it will jump through an ordinary wire, for this reason heavy cable must be used and kept away from the metal of the engine. A neat method of distributing the cables to sparking plugs on multi-cylinder engines is shown above. A divided fiber tube supported on brackets encloses the cables and allows of easy inspection or renewal, if required. Any number of leads or cables can be distributed. The eight plug leads required for dual ignition on a four-cylinder engine can be accommodated in a two-inch tube.

Note—The current flowing through the primary wires is of low voltage and will not jump through the insulation, but the primary wires must be carefully run so that they will not ground.

CHART No. 75B.


WATER = ELECTRICITY.
WATER CURRENT = ELECTRIC CURRENT.
WATER SUPPLY TANK = CURRENT SUPPLY (BAT. OR GEN.
PUMPS = INDUCTION COILS.
VALVE OPENING DEVICE = TIMER & ITS WIRES.
PIPES = OTHER WIRES.
HIGH PRESSURE PUMP OR COIL 1
PUMP OR C. 2
PUMP OR C. 3
PUMP OR C. 4
VALVE
OPENING DEVICE
VALVE
3
2
4
1
TIMER
HIGH PRESSURE PIPES OR SEC'DY WIRES
S. PLUG
S. P.
S. P.
S. P.
A
S
A
B
C
D
E
F
G
WATER SUPPLY TANK OR BATTERY.

In order that the reader may grasp the idea of how the electric current flows from the battery through the wire of the coil and is then distributed to the spark plugs in the cylinders of the Engine we will use a comparison of a Water System.

Imagine the "Water Supply Tank" being the battery or generator, the "Water Pipe A" as the wire to the primary wire of the coil; the "Valve S" as the Switch; the "Pump" as the Induction Coil; the "Valve Opening Device" as a Timer; the "Gap at S. P" as the points of a Spark Plug.

One Similarity is Extremely Useful to Remember; Electricity and Wiring Resembling Water and Piping. The Wire might be likened to the hole in the pipe and the insulation of the wire to the walls of the pipe. **Electricity**, then, is spoken of as flowing through a wire as water through a pipe. **Suppose we have a Tank of Water**, and a line of pipe having both ends connected to the tank. Means are provided for causing the water to circulate slowly through the tank and piping, as by introducing a low pressure pump into the system or charging tank itself with a certain amount of pressure.

In an Electric Current this pressure is produced in numerous ways. **The Most Common Methods** are by the magnetic and mechanical actions in a magneto, and the chemical action in a storage battery. We illustrate just such a system.

A Water Tank containing a certain amount of pressure takes the place of a charged storage battery; pipes are shown to represent the wires; and in order to further simplify matters, high pressure pumps represent the induction coil; a valve opening device or, as in this case, a four way valve, is likened unto the timer, a pet cock to a switch, and the whole system of parts likened in due order, as in the wiring diagram of an electric ignition system.

Tracing the Flow of Current.

We will now trace the flow of the water current; on opening the valve S, the water flows through pipe A and its connections to the valve opening device. As soon as the valve in this device is turned to one of the pipes the circuit is open and the water flows through and returns through the ground pipe G to the tank. **This Flow of Water Automatically Puts into Action** the corresponding pressure pump and a strong current of water passes swiftly through the high pressure pipe, jumps across the gap, which corresponds to that of the spark plug, and is also drained back to the tank through ground pipe G. Therefore it will be seen that as the valve, in the device, revolves, if it is properly set, intermittent squirts will take place across the appropriate gap at the proper time.

There are no Wires in an Electric Circuit Corresponding to Pipes B, C, E and F, the electric current being brought back to the ground wire, represented by pipe G, through the metallic conductivity of the motor. **An Electric Circuit is the Path** in which the electricity moves or, as we commonly say, the path through which the current flows.

In Motor Ignition Systems We Deal with Two Circuits—"primary," or low tension circuit and a "secondary," or **high** tension circuit; and the currents in each are known as primary and secondary, or low and high tension currents respectively.

CHART No. 76.

INSTRUCTION No. 15.

WIRING CONNECTIONS.—Make and Break System. Battery and Magneto. Jump Spark or High Tension Diagrams of Wiring.

While the Different Ignition Systems Require Different Wiring and connections, certain instructions apply to them all, and for successful results these must be carefully observed.

WIRE.

The Wire Used must be sufficiently large, in order that no current may be wasted in overcoming resistance.

The Wire That Gives the Best Service, and is most easily handled, is called FLEXIBLE CABLE, which is similar to electric light cord, and is made up of a number of fine wires twisted together.

The Insulation for Wires of the Primary Circuit, and for low tension currents, need not be as heavy as is necessary for high tension currents.

It Must Be Tough, and not liable to injury by the heat of the engine, or moisture.

In the Best Insulation for Secondary Wires, the fine wires are first covered with a fine rubber tube, which is then braided with several layers of cotton thread, each layer being soaked in rubber, and on the outside two layers of heavy linen or cotton thread for protection against chafing.

The Wire Used should be the kind made for the purpose; bell wire or other makeshifts will give unsatisfactory results.

CONNECTIONS.

All Conections Must Be Bright and Clean, for a dirty connection will set up resistance.

Binding Posts, screws, and the ends of the wire must be scraped clean before the wire is attached.

All Connections should be made as firm as possible, using pliers to tighten the binding screws.

The Best Connections are made by brass terminals soldered to the ends of the wires.

When a Connection has been screwed tight ,the binding screw and terminal should be covered with vaseline or paraffine, to prevent corrosion, and the whole wrapped with electric tape.

This Tape Comes in Rolls, and is sticky, so that it will stay in position when once applied.

In Addition to Being an Insulator, it prevents moisture from getting at the terminal.

Short Lengths of Wire provided with terminals are sold for making battery connections, and it is well to use them.

No Possible Cause for Leakage of the current should be allowed; a single strand of fine wire projecting from a flexible cable will be enough to cause a short circuit if it should touch metal.

A Ground Connection should be filed or scraped bright before attaching the wire, and the connection when made should be covered with vaseline or parafine.

A Copper Washer should be placed under the head of the screw, to hold the wire firmly in position.

WIRING.

When the Position of the Engine requires a wire to be of some length, it should be supported by binding it LOOSELY to some stationary part, using tape.

It Must Be Loose Enough to Vibrate Easily with the jolting of the car, but should be prevented from rubbing, for that would wear the insulation, and cause a short circuit.

Do Not Draw a Wire Tight from a stationary part to a part that moves (from the frame to the timer, for instance), for the wire will be liable to break inside of the insulation.

Extra Wire Should always be carried in the tool box, for breakage is liable to occur.

It Is Convenient to have it cut into lengths for any connection, and provided with soldered terminals, so that replacements may be made without wasting time in fitting.

BATTERY.

The Battery should be carried in a box made to fit, so that the cells cannot slide about.

The Spaces Between the Cells may be filled with cotton waste or folded paper to prevent movement, for that would be liable to loosen the connections or break the wire.

The Box Should Be of Wood rather than metal, for metal might chafe through the coverings of dry cells, and cause short circuit.

If the Box is of Metal, it should be lined with thin boards, or heavy pasteboard.

It Should Be Covered so that no moisture can enter, for that would lead to corrosion and would rot the insulation.

This Also Applies to All Parts of the Ignition System, for it must be remembered that moisture is a sufficient conductor to cause short circuits.

CONNECTING UP A MAKE AND BREAK SYSTEM.

The Make and Break or Low Tension Ignition System requires less care in wiring than the high tension or jump spark system.

The First Difficulties, which were insulating the stationary spark point, and making an easy working but tight joint for the moving spark point, have been largely overcome.

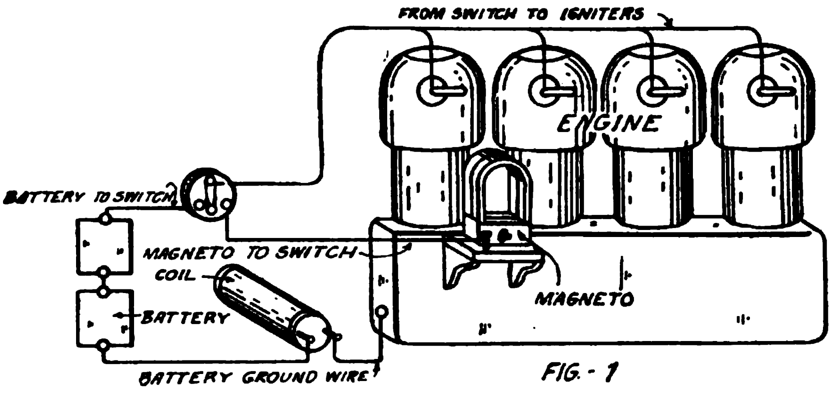


FIG. - 1

Fig. 1.—A Four Cylinder Engine Using a "Make and Break" Igniter with a Low Tension Primary Coil and Battery and a Low Tension Magneto.

Note the battery circuit uses a low tension coil (One winding) but when the magneto is switched on, the coil is cut out.

No timer is used. The "Make and Break" Igniter is operated from cam shaft and "Makes and Breaks" at the proper time itself. See Chart 66, fig. 1.

The principle and construction of a Low Tension and High Tension Magneto will be explained futher on..

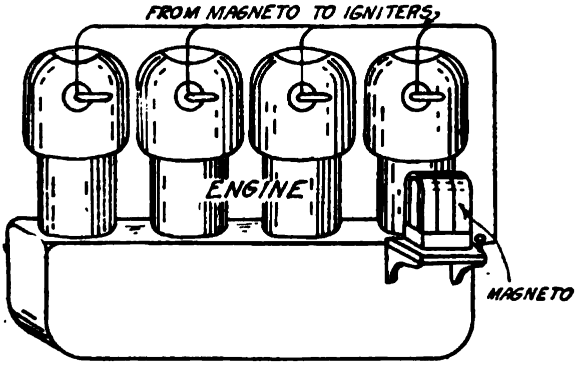


FIG 2

Fig. 2—Illustration Shows a Four Cylinder Engine with "Make and Break" Igniter Being Operated by a Low Tension Magneto.

Timer not used because the ignition system is the "Make and Break" and the "Make and Break" mechanism is operated mechanically by a cam.

CHART No. 77.

The Current is Usually Generated By a Magneto, a battery occasionally being used for starting.

BATTERY AND LOW TENSION MAGNETO.

When Both Battery and Magneto are Used, as shown in Chart 77, Fig. 1, as wire from each leads to the points of the switch, so that when the engine has started and the magneto is running fast enough to generate a sufficient current, the battery may be cut out and the magneto switched in.

The Current From the Battery not being of sufficient tension to produce a hot spark, the current from it is passed through a simple coil, which is usually placed in the circuit between the ground and the battery, as shown.

From the Switch Blade, the current is led to the igniter.

Thus the Flow of Current is From the Switch through the igniter, and by the metal of the engine back to the generator.

The Battery Requires a Ground Wire, but the magneto does not, for one of its terminals makes a contact with its metal base, which is bolted to the metal of the engine, being grounded when it is attached.

When the Spark Points of the Igniter are brought together by the cam, the current flows; when the points are separated, the spark forms between them, the flow of current instantly ceasing.

As Shown on Chart No. 77, there is but one circuit, and as the current is of low tension, it is not liable to leak.

The Wire may therefore be lightly insulated, but the insulation must be good and protected so that it will not chafe.

The Single Terminal of the magneto is connected to one of the switch points, the current flowing through the switch to the igniters, by the ground back to the magneto.

LOW TENSION MAGNETO ALONE.

Chart 77, Fig. 2, Shows the Connections When the Magneto Alone Is Used, which consists simply of a wire from the magneto to each of the igniters.

The Usual Connection is to pass the wire from the magneto to a bar of brass or copper, bearing four switches, or one for each igniter; each switch is connected to its igniter by a short length of wire.

These Switches provide a means of testing the action of the igniters when they are suspected of being out of order.

With This System, it is necessary to crank the engine in such a manner that the magneto will have speed enough to produce the required current.

Magnetos must be driven positively by gears, in order that there may be no slipping.

A Magneto does not deliver its full current at all times, for the current is strong at some parts of the revolution, and weak at others.

It Must Be So Set, therefore, that its strongest current is produced at the instant that the spark points separate.

CONNECTING THE JUMP SPARK SYSTEM.

The Coil Box is usually placed on the dash, but whatever its location may be, it should be carefully protected from moisture.

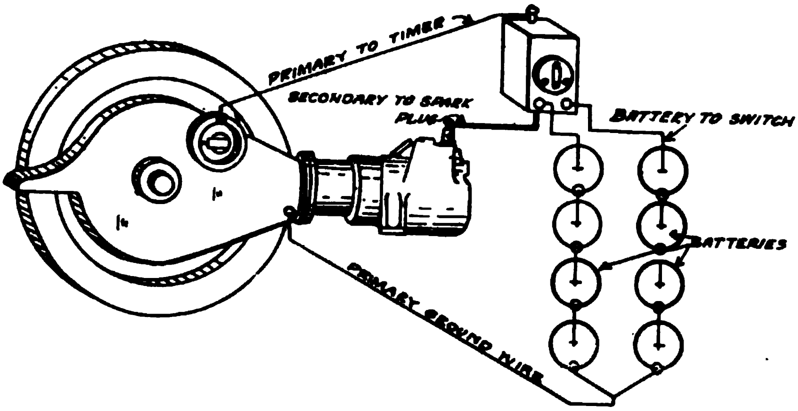


Fig. 1.—One Cylinder Engine with Jump Spark Coil and Two Sets of Dry Batteries for Ignition. Only one set of batteries in use at the time.

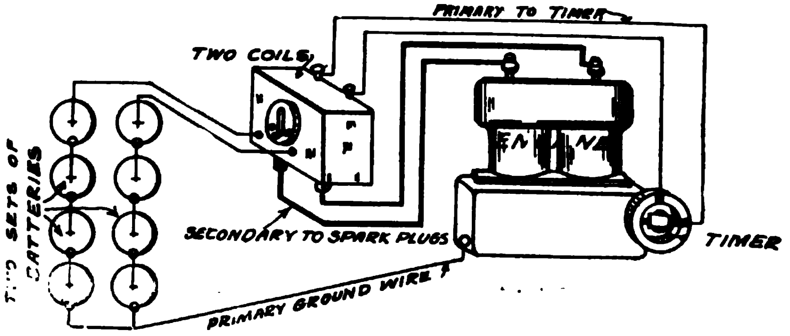


Fig. 2—Two Cylinder Vertical Engine with a Jump Spark Coil and Two Sets of Dry Cells for Ignition.

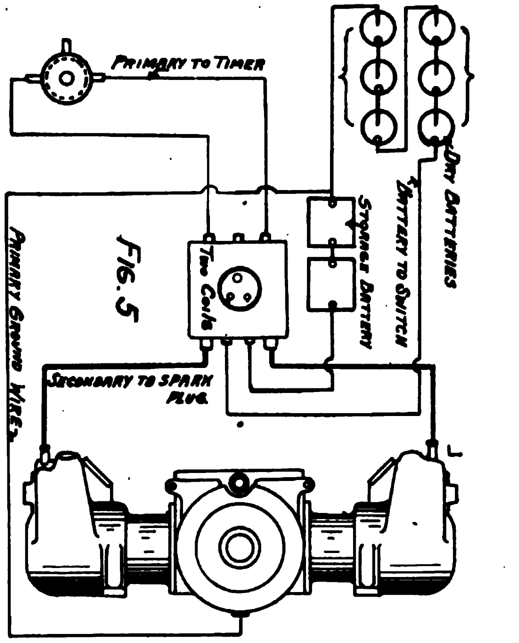


Fig. 3.—A Two Cylinder Opposed Type of Engine with a Two Cylinder Jump Spark Coil and a Set of Dry Cells and a Storage Battery, either of which may be used.

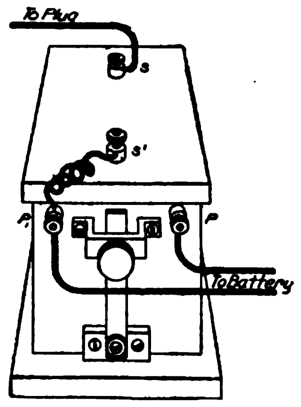


Fig. 4.—A Single Cylinder Jump Spark Coil. This Type is usually called a "Box Coil."

Quite frequently a single cylinder box coil has but one secondary connection on top. In this case the secondary connection shown at front of the coil is connected inside of the coil to the primary wire which connects to binding post P.

CHART No. 78.

For the System in most general use, the box contains as many coils, of the type shown in Chart No. 73, as the engine has cylinders. (There are 4 coils in one box in this illustration.)

The Switch is usually placed on the box, so that one battery or the other may be switched in, or the circuit broken.

The Binding Posts connecting the two sets of battery or the battery and magneto, are usually placed directly below the switch points.

The Connection From the Switch Blade to the winding of the coil or coils is made by the makers, and is inside of the box. ....

The Binding Post by which the primary current passes from the coil to the timer is at the top of the box.

The Current Thus Passes From the Battery to the Switch Point, through the switch blade and inside connection to the primary winding, from there to the binding post on the top of the box, through the connection to the timer, from the timer when it makes contact to the ground connection by the metal of the engine, and thence back to the battery by the ground wire.

The Secondary Current Leaves the Coil Box by a terminal at the bottom of the box, this position giving the binding post better protection against dampness.

This Binding Post is connected to the spark plug by heavily insulated wire.

After the Secondary Current has jumped between the points of the spark plug, it flows through the metal of the engine, and back to the coil box either by the battery ground wire and passing through the battery, or by the timer when it makes contact.

It is a Peculiarity of the Electric Current that two or more different currents may flow over the same ground wire, each returning to the place where it started, the different currents not being "mixed up" with each other, or changed in any way.

Thus One Ground Wire may be used for both the primary and secondary currents, the primary returning by it to the battery, and the secondary current returning by it to the secondary winding of the coil, neither current being interfered with by the other.

The Other—negative—terminals are grounded by being connected secondary currents, the primary returning by it to the battery, and the from the primary ground wire back to the secondary winding of the coil.

CONNECTING A ONE CYLINDER HORIZONTAL ENGINE.

When the Engine of an Automobile Has But One Cylinder, it is usually placed in a horizontal position under the body of the car.

The Location of the Battery, coil box or other parts of the ignition system depends on the design of the car.

The Switch Being on the Coil Box, one wire from each set of batteries, usually from their positive poles, is connected to one of the terminals, so that swinging the switch blade from side to side throws one or the other into circuit.

The Other—negative—terminals are grounded by being connected to the metal of the engine, using one wire for both. (Chart 78, Fig. 1.)

The Primary Terminal of the Coil Box, on top, is connected to the binding post of the timer; when the timer, in revolving, makes connection, the current flows through the shaft to which the timer is connected and through that and the metal of the engine to the ground wire and battery.

Thus the Only Primary Connections to be made are from the two sets of battery to the switch; from the batteries to the ground; from the primary binding post to the timer.

The Secondary Terminal of the coil box is connected to the spark plug.

TWO CYLINDER ENGINES

The Coil Box contains two coils, one for each cylinder, and is located on the dash. (Chart 78, Fig. 2.)

The Engine May Be Located forward of the dash under the bonnet, or in the center of the car, and the box containing the batteries is usually under the seat.

The Connections From the Batteries to the switch are the same, no matter how many coils there may be; that is, each set is connected to a switch point, and one ground wire for both.

The Timer Has Two Binding Posts, one for each contact point, and one primary terminal is connected to one of the contacts, the other primary terminal being connected to the other contact.

The Primary Circuit is completed when the timer makes contact, in the same manner as the timer completes the circuit for a one cylinder engine, or an engine with any number of cylinders; that is, the current flows from the battery through the primary winding of the coil, to the timer, across the contacts, and back by the timer shaft, and ground wire.

The Revolving Part of the Timer touches first one contact and then the other, sending the current from the battery through first one coil and then the other.

The Secondary Current passes through wires from the secondary terminal of the coil box to the spark plug.

When the Timer Passes the Primary Current through the primary winding of the coils, the secondary wire from that coil must lead to the spark plug of cylinder that is to be fired.

If the Wires are Cross-Connected, the engine will not run, for the spark will pass in the wrong cylinder.

At the Instant that the timer passes the battery current through the vibrator of one of the coils, the secondary current is formed in the secondary winding of that coil, and passing to the spark plug, jumps the space between the points, and returns to the secondary winding by the engine and the ground wire, or by the timer, whichever presents the least resistance.

It Must Be Remembered that the primary and secondary windings are connected inside of the coil box to permit this.

In the Timer Shown in Fig. 2, Chart 78, the crank shaft is supposed to be 180 degrees, which in Chart No. 43 was shown to produce two power strokes in one revolution, followed by a revolution without a power stroke.

The Contact Points of the Timer are separated by a distance that

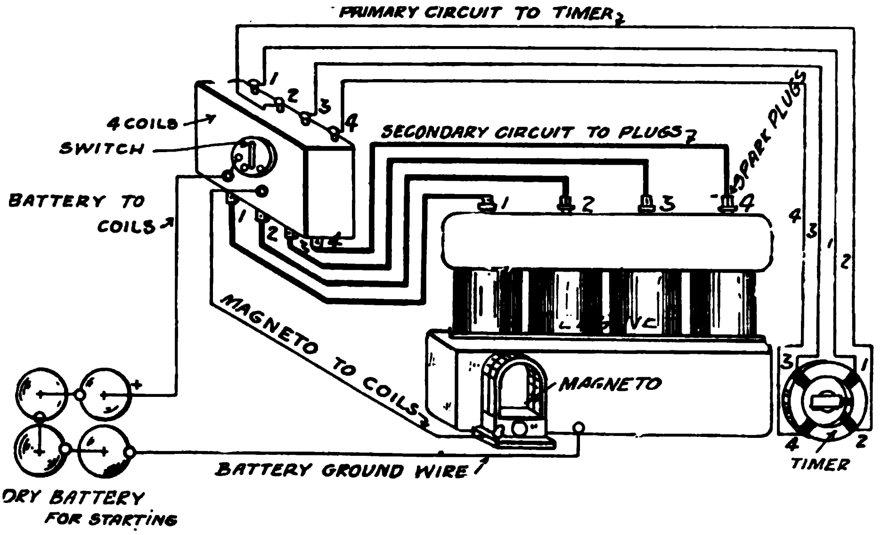


Fig. 1—A Four Cylinder Engine with a Four Cylinder Jump Spark Coil and Dry Batteries and a Magneto.

The dry batteries supply the electricity for starting the engine. The switch on the coil is then thrown over to the Magneto and the battery is cut out.

Heavy wires are secondary wires. Light lines indicate primary wires.

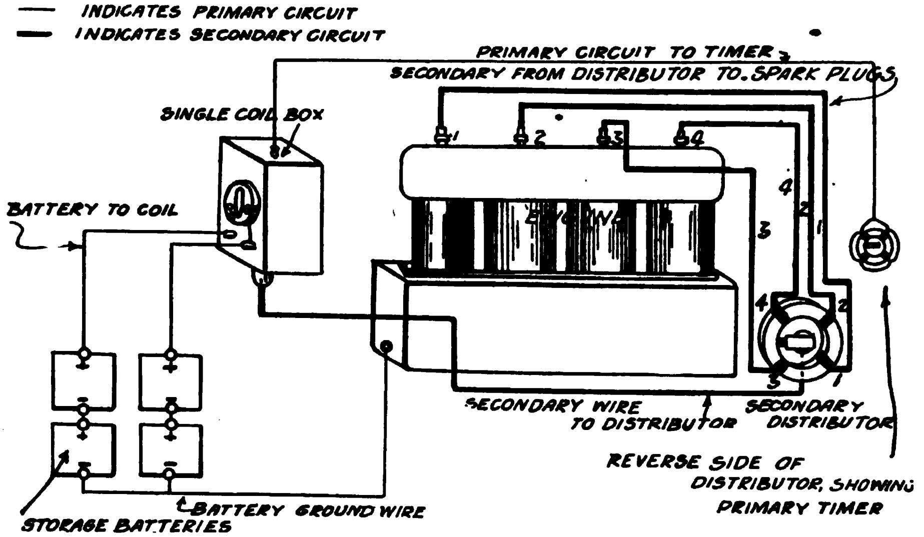

— INDICATES PRIMARY CIRCUIT
— INDICATES SECONDARY CIRCUIT
PRIMARY CIRCUIT TO TIMER
SECONDARY FROM DISTRIBUTOR TO SPARK PLUGS
SINGLE COIL BOX
BATTERY TO COIL
SECONDARY WIRE TO DISTRIBUTOR
SECONDARY DISTRIBUTOR
REVERSE SIDE OF DISTRIBUTOR, SHOWING PRIMARY TIMER
BATTERY GROUND WIRE
STORAGE BATTERIES
1
2
3
4

Fig. 2—A Four Cylinder Engine using a Single Coil and a Distributor.

The secondary current is distributed to the four cylinders by a secondary distributor shown above.

The Timer is usually placed on the opposite side of this Secondary Distributor (both being operated by the same cam shaft) and the timer performs its usual function of opening and closing the primary circuit. Both the timer and secondary Distributor open and close the circuit at the same time. This prevents "arcing" of the secondary from brush to Segment. (See Chart 75 Fig. 1.)

CHART No. 79.

requires the crank shaft to make a half revolution in order that the moving part may move from one contact to the other, and then a revolution and a half to move it to the first contact point again.

If the Crank Shaft of this Vertical Engine were 360 degrees, the contacts would be on opposite sides of the timer, like the timer shown in Fig. 3, so that the crank shaft would make a full revolution to turn the moving part from one to the other, because a crank shaft of this kind permits a power stroke every revolution.

Because a Horizontal Double Opposed Engine permits a power stroke every revolution, this last described timer is used on it.

The Wiring of This Type of Engine, shown in Fig. 3, Chart 78, is the same as that described.

FOUR CYLINDER VERTICAL ENGINE.

The Wiring of a Four Cylinder Vertical Engine is the same in principle as that of engines with fewer cylinders, there only being an increase in the number of parts.

It must be remembered that, for reasons given in Chart No. 43 the order in which the explosions occur in the cylinders is NOT REGULAR, 1, 2, 3; 4, but IRREGULAR, being 1, 3, 4, 2, or 1, 2, 4, 3.

While Either of These May Be Used, according to the action of the exhaust valves, the former, 1, 3, 4, 2, is in most general use, as the engine is considered to run with less vibration than with any other firing order.

The Wiring Connections must be made to correspond with the setting of the valves, that the timer may make contact and the spark pass in the proper cylinder.

It Must Be Understood that the proper connections are made in the coil box by the makers to permit the secondary current to return to the secondary winding over the battery ground wire.

Referring to Fig 1, Chart 79, it will be seen that connections are made between the primary terminals of the coil box and the timer, so that the current of No. 1 leads to the contact at which the timer makes connection when cylinder No. 1 is at the end of the compression stroke and ready to fire.

As the Timer Revolves, the next contact to be completed should be connected to the coil that produces the spark in the next cylinder to fire, which may be either No. 3 or No. 2.

Cylinder No. 4 Fires Third, and therefore coil No. 4 should be connected to the next timer contact, and No. 3 or No. 2 to the last contact of the timer.

The Connections between the secondary terminals of the coil box and the spark plugs are in regular order; coil No. 1 to spark plug No. 1, coil No. 2 to spark plug No. 2, and so on.

FOUR CYLINDER VERTICLE., ONE COIL.

In This System only one coil is used for the four cylinders, the secondary current being switched from one to the other by a DISTRIBUTOR, the principle of which is the same as that of a timer. (See Chart No. 79, Fig. 2, and Fig. 1, Chart 75.)

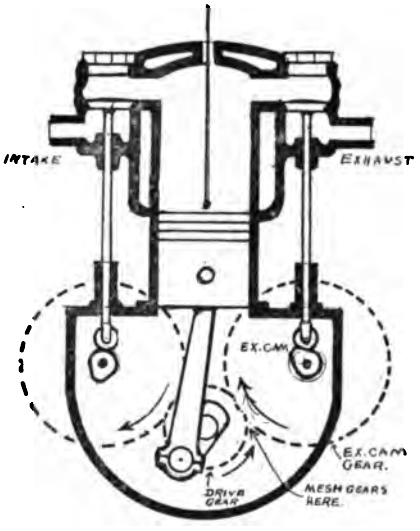


Fig. 1—Setting the Valves.

Piston nearly at end of firing stroke.

Mesh exhaust cam gear so that exhaust valve is just beginning to raise.

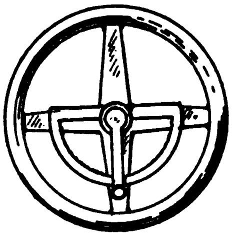


Fig. 2.

Place spark lever in center of quadrant so that it can be "advanced" or "retarded."

The spark lever is connected with the timer on the engine.

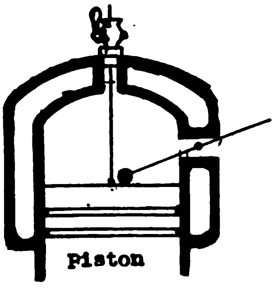


Fig. 3.

Method of locating position of the piston either through spark plug hole or compression cock.

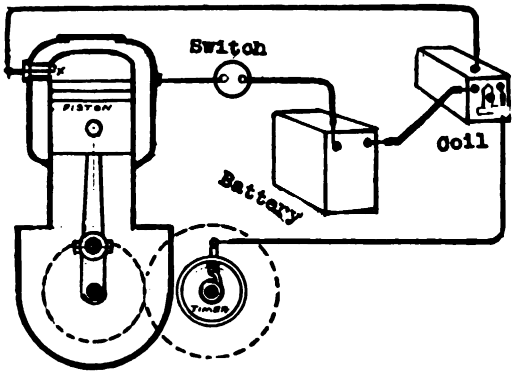


Fig. 4—Timing the Ignition for Jump Spark System.

Place piston on compression stroke.

Set timer so that contact will be made.

Arrange Timer in center position so that it can be "retarded" or advanced."

CHART No. 80.

INSTRUCTION No. 16.

IGNITION TIMING.—Rules for Setting Valves and Timing the Ignition. Verifying the Ignition Timing. Range of Spark Advance and Retard Spark Control and Overheating.

RULES FOR SETTING VALVE AND IGNITION TIMING.

An Engine Must Always Be Timed Firstly From the Exhaust and Inlet Valves and not from the timer and spark. To take as an example an average single cylinder engine to proceed to set the two-to-one gear wheels, the piston should be nearly at the end of the firing stroke (some engines work better with more exhaust "lead" than others, but one-sixth is an average amount); then, whilst the piston is in this position, take the exhaust cam wheel and mesh the teeth with the small wheel, so that the exhaust valve is just beginning to be pushed off its its seating. (See Chart 80, Fig. 1, also see Chart No. 99A.)

Next, Move the Engine Wheel Round in its direction of rotation and carefully note if the exhaust just shuts down on its seating just before the piston has commenced the down or inlet stroke. If this is so, the exhaust valve timing is approximately right.

Should the Exhaust Valve Close Too Early, move the larger gear wheel back by one tooth and try again.

The Larger the Number of Teeth on the Gears for a given diameter the more accurately the timing can be set.

If the Inlet Valve is Automatic, the timing has not to be considered, but mechanically-operated valves have to be separately timed to open immediately the piston begins to descend on the induction stroke by meshing the pinions as for the exhaust valves.

Next, as to the Setting of the Timer for Coil Ignition.

Supposing That the Spark Lever is Mounted on a Ratchet Quadrant, fix it in a midway position and then set so that this adjustment of the lever keeps the timer in such a position that the spark occurs just at the moment the piston has completed the compression stroke. (See Chart 80, Fig. 2 and 4.)

This Should Allow Ample Range For Retarding and Advancing, but a trial should be made with the engine running, and a note made as to how the speed responds to the advance and retard movement and variation in setting made if found necessary.

The Amount of Advance that can be given to any motor depends on certain variable factors.

It is Not Possible to Have as Much Advance on the ignition when the motor is running under a load as when it is running light and at a fast rate.

TO FIND THE POSITION OF THE PISTON.

To Find the Position of the Piston in the Cylinder, the most convenient way is to take the screw plug, or compression cock, out of the combustion head and insert a piece of straight wire, **such as a spoke.** (Chart 80. Fig. 3). Then mark the beginning and end of the piston stroke with a file scratch, and then subdivide in between six equal parts. Where it is not possible to insert a wire vertically through the cylinder head a pivoted wire may be introduced through the plug aperture if at the side of cylinder. The wire can be fixed in a plug shell, the inner end being weighted to rest on the piston.

Another Way, when there is no means of inserting a wire into the cylinder, or access to the crank through an inspection plate, is to take off the cylinder and fix a slip of wood vertically alongside the piston and mark the top and bottom of the stroke on this.

A Center-Punch Mark can be made on the fly-wheel and another one exactly corresponding to it on the crank case. When the two marks coincide it will indicate that the piston is, say at the top of its stroke.

Then Turn the Wheel Round—in the driving direction; and when the piston is at the bottom of its stroke make two marks on it to coincide with the fixed mark on the crank case.

Then, if it is Necessary at Any Future Time to reset the timing gear, it can be done without dismantling the engine.

On Many Engines an intermediate pinion is used between the large and small timing wheels, but the actual teeth engaging on the intermediate has not to be considered unless certain teeth are found marked. The important factor is that certain teeth on the large and small pinions mesh simultaneously through the intermediate pinion.

When the Accuracy of the Timing is Being Tested it is worth while taking care to see that the exhaust and inlet valves have a maximum amount of lift.

There Should Be Not More Than 1-32d inch—preferably less—clearance between the valve tappet and the valve stem. The amount of clearance, as a little consideration will show, will effect the time of the valve opening.

If the Clearance is Excessive the valve will open late, and the exhaust gases will be throttled, with consequent loss of power.

Unless the Valve Tappet or Lifter has an adjustable cap to allow for clearance being reduced, the only remedy is to rivet or braze a piece of steel on the end of the tappet or valve stem, or fit a new valve with a longer stem.

Wear of the Cam Profile also reduces the lift of the valve. This wear does not often assume serious proportions in a well-designed engine, as the steel cam is made very hard and kept well lubricated.

Most Engines now have indicating or timing marks on the flywheel (clutch) of engine, so that there is not much trouble in resetting the timing. If this is not done it is a good plan to make a set of marks corresponding to the top and bottom position of the piston, so that these can be read off relative to a fixed pointer or index.

Usually it Will Be Found that the gear wheels are marked.

If a Single Tooth is Marked it is intended to mesh in between two others so marked.

In Multi-Cylinder Engines particular care should be taken to get the high-tension cables connected up to the correct cylinders, otherwise the firing would be in the wrong order.

If the Timing of One of a series of cylinders is set correct, the others are bound to be right also, assuming that the cams and lifts are all in order and show no wear.

Where the Inlet Valves are Mechanically Operated from an independent cam shaft, it will be necessary to time these in addition to the exhaust valves.

A Good Rule is to set one cylinder so that the inlet does not begin to open till the piston is 3-16ths down, and it is an advantage to HAVE IT CLOSE SLIGHTLY LATE, i. e., JUST AT BEGINNING OF COMPRESSION, as a little extra time is thereby allowed for the gas to flow in and fill the cylinder.

Note—See Chart No. 99A.

VERIFYING THE IGNITION TIMING.

It Occasionally Happens that cars turned out of the factory hurriedly to meet pressure of orders are not as well adjusted in the setting of the ignition timing as they might be, with the result that the car may not prove an easy starter.

Even With the Full Retardation Given there is the ever present risk of the starting handle being shot backwards and injuring the operator.

In Such Cases it is advisable to verify the spark timing to see exactly how things are.

The Beginning and End of each piston stroke should be indicated by marks stamped on the fly-wheel corresponding with a fixed mark somewhere on the frame. This saves a lot of time in the event of the timing having to be verified, taking one cylinder of a two or four.

It May Be Necessary to find the beginning and end of the stroke by inserting a piece of stiff straight wire through the compression tap opening as previously described, these points being indicated by the wire descending as far as it will go and rising to its highest point.

It Should Then Be Noted Exactly where the advance lever (on steering wheel) is when the contact sector (on timer) is touching the brush at the instant that the piston is beginning to descend (or, in the case of a high-tension magneto, the platinum contacts should just be separating).

If the Contact Disc is Keyed at the right place on the shaft—that is, with its sector nearly 180 degrees past the exhaust cam center—and the lever is correctly set, this latter will be about the center of the quadrant, thus producing the spark as the piston is going down.

If It Be Found That the Lever Has to Be Pushed Right to the End of the quadrant to get the spark to occur just past the dead center, as it is termed, it will be evident that there is not sufficient retardation available.

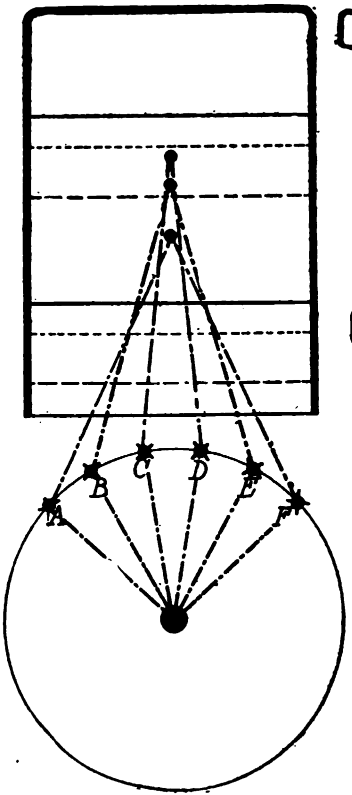
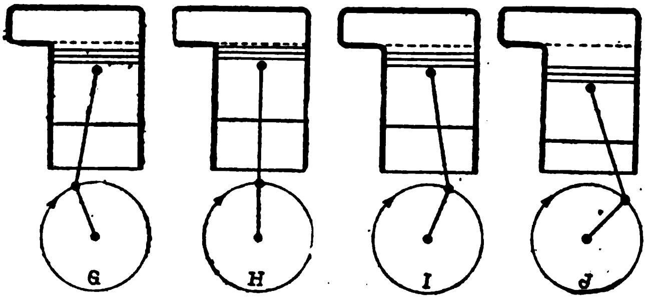


Fig. 1—Range of Spark Control.



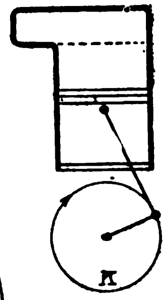


Fig. 2—Diagrams showing when sparks should and should not occur.

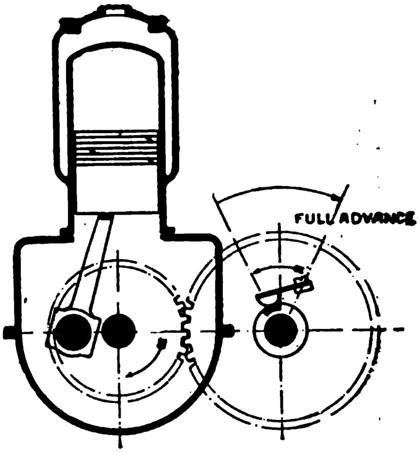


Fig. 3—Coil ignition timing diagram showing approximately piston and contact maker positions for full advance. Owing to the lag and inertia of a coil trembler considerable range of advance is required to obtain the spark at the most effective position of the piston.

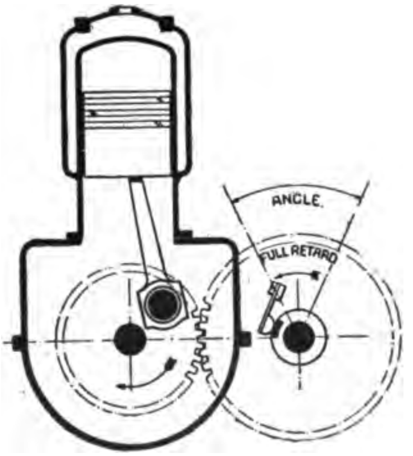


Fig. 4—Ignition timing diagram showing approximate positions of contact maker and position of piston for fully retarded spark. The angle of movement of contact maker is shown to make the principle clear, considerably greater than obtains in practice. For a high tension magneto instead of a coil the same principle applies, the only difference being that the contact on the magneto is a make and break, the spark therefore occurring at the "break" instead of at the make as with a wiping contact. The magneto will run at the same speed as the crankshaft.

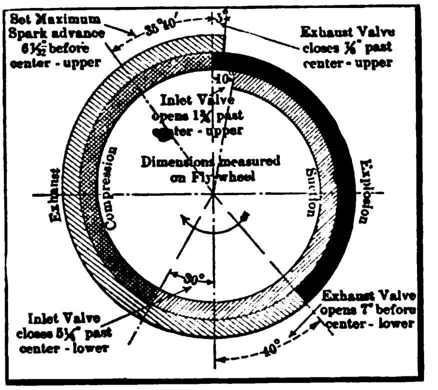

Set Maximum Spark advance 6 1/32° before center - upper
35° 40′
3°
Exhaust Valve closes 3/8° past center - upper
10°
Inlet Valve opens 1 3/4 past center - upper
Dimensions measured on Fly-wheel
Exhaust
Compression
Suction
Explosion
30°
Inlet Valve closes 5 1/4° past center - lower
Exhaust Valve opens 7° before center - lower
40°

Fig. 5—The timing of the valves and ignition of various engines differs to some small extent, the best setting being determined by experiment. This diagram illustrates the valve setting adopted in a standard make of engine. It will be noted that the exhaust valve opens well before completion of firing stroke and closes well past dead center, and inlet valve does not close till beyond the lower dead center. Crank path is from left to right.

CHART No. 81.

With Magneto Ignition it may be assumed that the spark occurs at the instant the platinums separate.

An Approximate Rule for late ignition to allow for safe starting is that the spark should occur about one-fifth down on the firing stroke, and for full advance four-fifths up on the compression stroke.

It is as Well to Make Two Marks on the crankcase corresponding to this range of the contact maker, and then work from this to adjust the advance lever.

RANGE OF SPARK ADVANCE AND RETARD.

In Chart 81, A Diagranm is Shown, the range of spark advance and retard, representing different positions of a crankshaft, and the relation of the piston in the cylinder at these different positions.

Referring to This Diagram if a Motor is running at an extremely high rate of speed, the spark might be advanced so as to occur in the cylinder when the throw of the crankshaft is ascending and at the point A, thus combustion might be complete or so near complete by the time the throw reached the point D, that a very strong pressure would be exerted upon the piston, which is as it should be.

If the Motor Were Being Subjected to an Extremely Hard Pull as in ascending a hill on high gear, so that its speed is considerably reduced, and ignition were to take place at A, combustion might be complete at B or C, and the pressure or power-impulse on the piston head would tend to turn the crankshaft in a reverse direction.

If the Car Were Traveling at a Very Low Speed or if there were not sufficient momenetum in the fly-wheel or the car itself, the motor would be stalled, or killed as the saying goes.

Of Course if the Car or Motor Were Traveling at a Sufficiently High Rate of Speed to Carry the Shaft and Piston Over This Dead Center a large percentage of the power would be applied in the right direction, but considerable would be lost, there would be what is known as an ignition knock, and the strain on the bearings would be quite severe.

On the Other Hand, if the motor has been slowed down considerably under hard pull and the ignition is retarded so as to occur at about C or D, combustion might be complete at about E or F, or perhaps even a little farther down where the leverage on the crankshaft is greatest, and thus the greatest amount of the downward pressure on the piston is utilized.

It Must Be Remembered that the greatest power is dependent upon the momentum or torque of the fly-wheel.

A Motor Always Should Be Run With the Spark Advanced as Far as Possible Without Causing the Motor to Knock or Loose Power, and a motor will overheat if caused to run for any great length of time with a retarded spark.

SPARK CONTROL AND OVERHEATING.

As Few Motorists Really Understand Just How the Power Efficiency of a Motor is Affected by the Spark-Timing which is generally under the control of the operator, the following may be of interest.

When a Combustible Mixture Has Been Compressed in a Cylinder by the Rising Piston and the spark occurs, a very small portion of the mixture in the immediate vicinity of the spark is ignited; and if the mixture is of the proper proportions and suitably compressed, the flame propagation throughout the entire combustion-chamber will be rapid.

This is as it Shoud Be. When Combustion Takes Place, intensely heated gases are formed which in their effort to occupy a larger volume of space, exert great pressure on the walls of the combustion chamber and upon the piston head.

As a Gas or Gaseous Mixture Is Compressed it Becomes Heated, and the greater the pressure the greater the heat.

If a Mixture is of Proper Proportions, the greater the pressure the more readily will it ignite and the greater the speed of flame-propogation or combustion.

On the Other Hand, as the pressure of a combustible mixture is reduced, it loses its heat, and its speed of ignition and combustion is is also reduced.

Thus It Must Be Understood that to get the utmost efficiency out of a combustible charge, it must be ignited at or near the point of maximum compression.

Several Interesting Conditions May Be Shown With the Diagrams of Fig. 2, which like Fig. 1, represents different positions of the crankshaft, and of the pistons in the cylinders.

Let It Be Assumed that a car is being driven at a speed of about 30 miles per hour, and that the motor is necessarily turning over at a speed of about 800 revolutions per minute, the spark lever advanced so the spark occurs when the pistons are ascending as at G.

Ignition, We Will Assume, is complete at H, and combustion at I, at which point the maximum pressure of the expanding gases is being exerted.

Under These Conditions, the motor runs smoothly and cool.

Now by Retarding the Spark and advancing the throttle levers, it is found that the speed of 30 miles an hour still can be maintained.

The Motor is Generating the Same Amount of Power, but with the spark retarded and the throttle advanced; but after a 30 minutes running the radiator begins to steam and we see that the motor is overheated.

What is the Cause? It is this.

The Spark is Retarded so that now it occurs when the piston is at I, compression is already reduced so that ignition is slower and is not complete until the pistons are at J, and combusiton is still incomplete at K.

The Explosive Mixture is Now Richer in Fuel so that more heat is given off than under the first mentioned condition, therefore, the expansive force is greater than before, so that the speed of the motor is the same, but note the wall surface of the cylinder at K, which now is exposed to this more intense heat.

The Water in the Jackets not only has to take care of the heat absorbed by the walls of the combustion chamber, but also of an excessive amount absorbed by the cylinder walls.

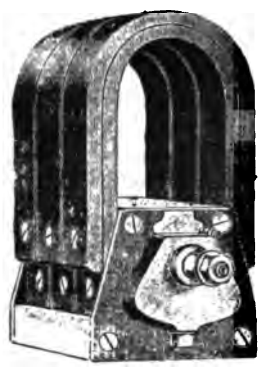


Fig. 1

Fig. 1—Illustration of a Low Tension Magneto

The Low Tension Magneto has but one winding on the armature. The voltage or tension of the current generated is of low pressure.

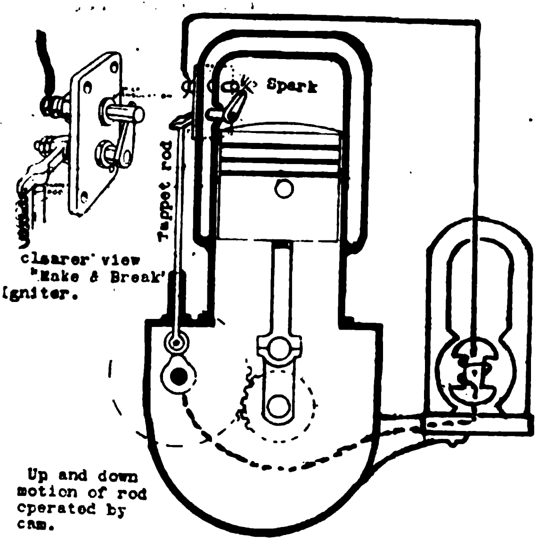

Spark
Tappet rod
clearer view "Make & Break" igniter.
Up and down motion of rod operated by cam.

Fig. 2—The Low Tension Magneto is usually used with a "Make & Break" system of Ignition

The "Make and Break" arrangement, operated by a cam, takes the place of a timer. The electricity does not jump across the space at the point of a spark plug in this system the pressure or voltage of electricity is too low. The spark is made by breaking the two ends of the wires suddenly—a device called a "Make and Break Igniter," operated by a plunger rod.

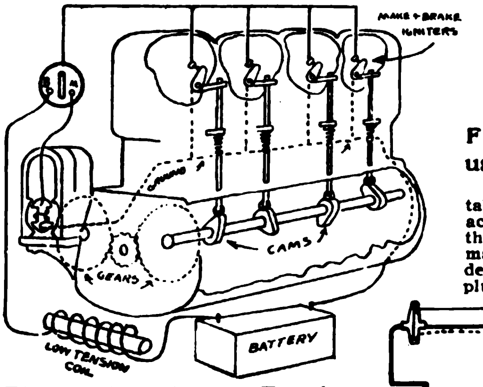


Fig. 3—The Low Tension Magneto or Battery, for Ignition, on a Multiple Cylinder Engine.

Either one can be used. Note that a low tension or single wound coil must be used in the circuit if the battery is used, whereas if magneto is switched on instead of the battery, the winding on the armature acts as a coil. Note the cam shaft operates the "Make and Break" igniters.

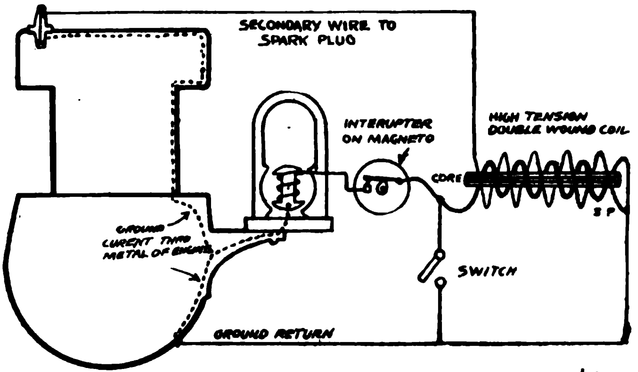

SECONDARY WIRE TO SPARK PLUG
INTERRUPTER ON MAGNETO
HIGH TENSION DOUBLE WOUND COIL
CORE
S P
SWITCH
GROUND CURRENT THRO METAL OF ENGINE
GROUND RETURN

Fig. 4—A Low Tension Magneto and a Separate High Tension Coil

The interrupter must be connected to the armature shaft. The cam which is attached to armature "makes and breaks" the circuit and acts in place of a timer and in place of a vibrator on the double wound coil.

In this system the high tension coil affords pressure enough to force the current across the gap of the spark plug. The spark plug is used for the igniter in place of the "make and break" arrangement.

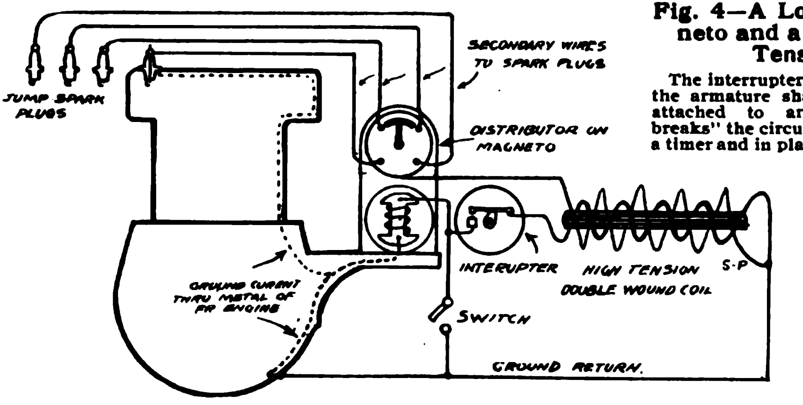

JUMP SPARK PLUGS
SECONDARY WIRES TO SPARK PLUGS
DISTRIBUTOR ON MAGNETO
INTERUPTER
HIGH TENSION DOUBLE WOUND COIL
S-P
SWITCH
GROUND CURRENT THRU METAL OF ENGINE
GROUND RETURN.

Fig. 5—A Low Tension Magneto with a Distributor Mounted Thereon.

It distributes the high tension current from the high tension coil to a multiple of cylinders—This is necessary when there is more than one cylinder. The interrupter is mounted on the end of the armature of magneto and also takes the place of a vibrator on a coil. A spark plug is used instead of the "make and break" igniter.

CHART No. 82.

THE DIFFERENT LOW TENSION MAGNETO SYSTEMS

INSTRUCTION No. 17.

VARIOUS IGNITION SYSTEMS:—Their Advantages and Disadvantages.

We Have Now Mastered the Various Forms of Coil Ignition, including the "Low Tension Coil System" with its "Make and Break" Igniter and the "High Tension Coil System" (Jump Spark) with its "Spark Plug" Igniter.

We Learned that We Could Operate the low tension coil or the high tension coil with dry cells, storage batteries or a dynamo.

Before Taking Up the Subject of Magneto Ignition (alternating current) we will summarize the various forms of ignition previously explained and then point out their defects in order to better explain why the magneto is the now popular and favorite form of ignition.

DISADVANTAGE OF A DRY BATTERY AND A COIL.

Dry Cells Were Never Intended for "Steady" Work, that is, for work where they are to be used more than a few minutes at the time. They were made for intermittent service; for ringing door bells, telephones, and service of like nature, where they are not in constant service and only for a few minutes at the time.

A Battery of Five or Six Dry Cells when fresh will do fairly good work on a single cylinder engine for short periods of work, but on multiple cylinder engines where the work is 3 or 4 times as great they are not reliable.

Dry Batteries Supplying Current for a Four Cylinder Coil would soon drop in voltage and their amperage or quantity would be rapidly consumed. In fact, dry cells are unreliable at all times. The writer knows of incidents where even new batteries just purchased were really old and had been on the shelf for some time and were dried up and practically useless.

A STORAGE BATTERY AND COIL.

Storage Batteries Are an Advantage Over Dry Cells in that they will at least maintain a steady pressure or voltage during the life of a charge and they do not drop in voltage or pressure while being used or until their amperage or quantity of current originally put into them is consumed.

For Instance; if your battery is a 60 ampere hour battery and 6 volt pressure, your coil consumes, say, 1 ampere of current per hour, then a fully charged storage battery will deliver one ampere of current at a steady pressure of six volts for 60 actual hours, whereas, the dry cell would soon drop in voltage or pressure and the vibrator would become sluggish and slow in action, due to the lack of pressure to force the current through the winding of the coil.

The Storage Battery Must Be Recharged and It Is Not Always Reliable, because the operator must watch and keep tab on the time actually in use for fear it will run down. Another objection is the acid solution, which is sloppy and corrodes all metal parts.

The Life of a Storage Battery is of short duration compared to their cost—probably due to the jolting of the paste from the plates which drops to the bottom of the jar and short circuits the plates. Very few concerns who recharge storage batteries give them the proper attention.

After a Storage Battery is Run Down it must be taken to a charging station and recharged and quite frequently overhauled. The time, expense and annoyance is the chief objection to this form of electric supply.

The Storage Battery Is an Excellent Auxilliary source of electric supply in connection with a magneto system.

A MASTER VIBRATOR COIL IN CONNECTION WITH A MULTIPLE JUMP SPARK COIL SYSTEM.

This is an Excellent System to Use in Connection With a Regular Jump Spark Coil System (when there are more than one cylinder.)

The Separate, Single Wound Master Vibrator Coil is Simply Connected in Series with the regular coil on the dash. (See Fig. 4, Chart 75.)

In Wiring It up You Simply Short Circuit the Vibrators on your regular high tension coils by screwing the platinum pointed adjusting screws down so that the vibrators will not work, but remain connected together.

The One Vibrator on This Master Vibrator Coil will then vibrate for all cylinders.

No Other Part of the System is Disturbed, the timer takes care of the distribution of current to the various cylinders as usual, the only difference being that the one vibrator does the work of all the vibrators.

This System is Also Called a Synchronous System.

A DYNAMO AND COIL.

A Dynamo (Don't confuse it with a magneto—a magneto generates an "Alternating" Current, meaning that the current is not always flowing North and South, but alternating—whereas the current from a Dynamo flows steady, from North to South and therefore is called a "DIRECT" Flow of Current) cannot be successfully used for ignition on an automoble engine owing to the variations of speed and consequently a variation of voltage or pressure. It does very well on slow and steady speed **Stationary** engines but not for high speed and variable speed automobile engines, unless means are provided to keep the pressure steady.

Some Manufacturers Run the Dynamo From the Engine Shaft and Have it Charge a Storage Battery by means of a "cut out" arrangement which keeps the current from flowing back into the dynamo when running slow. The storage battery then supplies electric current for ignition and also for electric lights.

This System is being adopted by some manufacturers.

It Is an Ideal System for Stationary Gasoline Engines of slow and a steady speed, also well adapted for ignition and lighting of launches.

VIBRATORS STICK ON COILS.

On Going Back to the Jump Spark Coil System of ignition again.

In Order to Get a "Fat" Spark at the points of the spark plugs with a jump spark coil system it is necessary to have back of that coil a storage battery that will **constantly** hold up its pressure or voltage but the objection here is the sticking of the platinum points on the vibrator with that of the adjusting screw.

A Pressure Strong Enough to Insure a "Fat" Spark at the Plug Points Will Cause the above mentioned platinum points to occasionally weld together and stick, thereby causing missing of explosion.

This is Quite Frequent where multiple cylinder coils with vibrators are used—yet on the other hand if this current IS NOT STRONG THEN THE SPARK WILL BE WEAK AND "THIN" and the gas will not ignite quick enough to obtain the best speed or power—therefore we must overcome this objection.

A SINGLE COIL AND A DISTRIBUTOR.

The Best Form of the Jump Spark Coil Ignition is the System of Using One Vibrator Coil and a Distributor for a multiple of cylinders. (See Chart 75.)

One Vibrator Coil only is necessary. The primary electric current passes through the coil in the usual manner, but the secondary or high-tension wires are distributed to the various cylinders at the proper time through a distributor.

THE BEST FORM OF IGNITION IS THE MAGNETO.

Because We Dispense With coils, batteries and sticking vibrators.

Another Reason is the Magneto supplies a flame with intense heating effect, firing even a weak charge readily.

The Magneto Gives a "Fat" Spark and does so continuously.

The Only Objection to a Magneto is in starting the engine; in order to start an engine with a magneto the starting crank must be turned quick and fast and sometimes it is necessary to "spin" the crank shaft of the engine in order to turn the armature on the magneto fast enough to cause it to generate sufficient supply of electricity to ignite the gas.

For This Reason We Find Cars Equipped With a Magneto and a Coil System. The coil system is used to start the engine, then the switch on the dashboard is turned on to the magneto and the magneto used continuously.

The Coil System is Also Used as an Auxilliary System when used in conjunction with the magneto in case the magneto breaks down or gets out of order.

THERE ARE SEVERAL DIFFERENT MAKES OF MAGNETOS.

There Are Several Makes of Magnetos on the market.

The Fundamental Principle of the Magneto, however, remains the same and after the reader learns the principle and construction of a magneto he will easily understand the different systems.

THERE ARE REALLY BUT TWO TYPES OF MAGNETOS.

In General Use; the Low Tension Magneto with a Single Wound Armature and the High Tension Magneto with a Double Wound Armature.

THREE MAGNETO SYSTEMS IN GENERAL USE.

There Are Three Systems in general use. They will be briefly mentioned here and described separately further on.

THE THREE SYSTEMS IN GENERAL USE.

(1) **The Low Tension Magneto** with a "Make and Break" system of ignition.

(2). **The Low Tension Magneto** with a "Jump Spark or High Tension Coil" and a spark plug.

(3) **The High Tension Magneto** system.

MAGNETOS GENERATE ALTERNATING CURRENT.

Both the Low Tension and the High Tension Magnetos Generate an "Alternating" flow of electric current, whereas the Battery and Dynamo generate a "**Direct**" flow of current.

THE DUAL SYSTEM.

Great Number of Cars Have a Jump Spark Coil and a storage battery, separate and independent from the Magneto, but both systems using the same set of spark plugs—this system is called "A Dual" Ignition System.

THE "DOUBLE" SYSTEM.

Sometimes a Car Will Have a jump spark coil and a magneto system, but with **two** sets of spark plugs—this system is called a "Double" System.

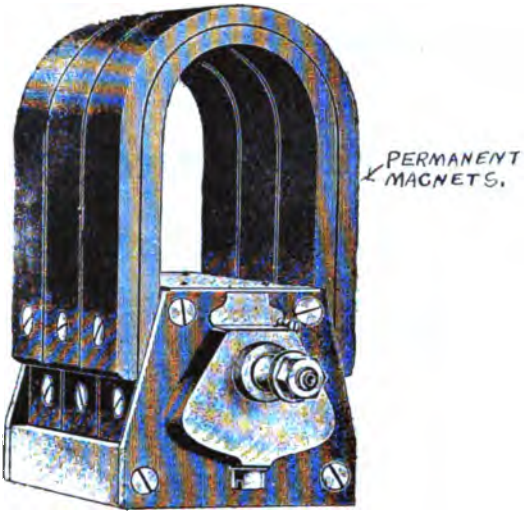

PERMANENT MAGNETS.

Fig. 1—End View of a Low Tension Magneto.

The drive end is shown.

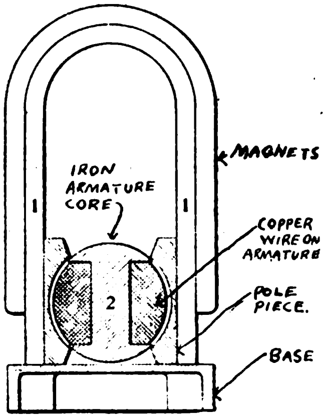


Fig. 2—View of a Low Tension Magneto with the end plate off and armature shown in section.

1—Permanent magnets (magnetized at all times).

2—The armature, revolved by a gear connected with engine shaft.

Note that a single winding of insulated copper wire is wound on the armature.

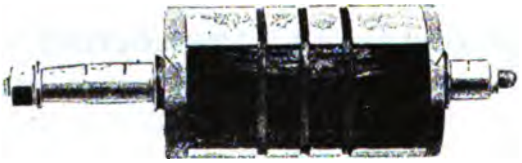


Fig. 4—Low Tension Armature with winding complete. (Single winding)

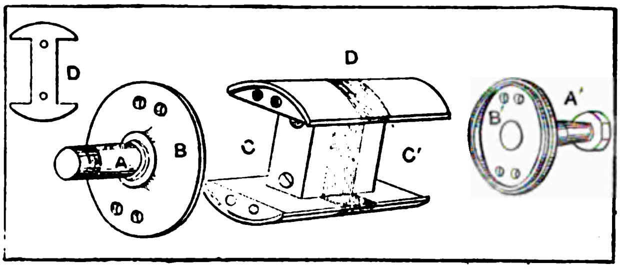


Fig. 3—The Armature of a Magneto before the wire is wound on it.

This type of armature is called a "shuttle" or "H" type.

Bronze heads B B' are screwed to the armature core C and C'

Shaft A A' are driven and riveted to bronze heads. Wire is wrapped around space C C'.

It will be seen that the core is not a solid casting; rather it is a pair of castings between which is clamped a group of soft iron stampings. D having the form shown in the detail sketch. The object of thus laminating the core, as it is called, is to retard the circulation of "eddy currents" in the core due to induction. The same forces of induction which are at play in the windings, operate also in the iron core itself, and if unchecked would both consume power and heat the armature unduly. As the voltage of these currents is very low, even the slight obstruction of the laminations is sufficient to retard them.

The laminated section of the armature is shown at D.

Laminated means that instead of the casting C being solid there are several layers of flat iron placed together as shown at D.

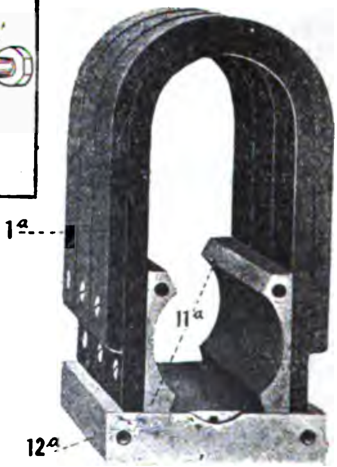


Fig. 5—View of Magneto with Armature out.

11a—Pole Pieces (Iron)
1a—Permanent Magnets (Iron)
12a—Brass Base.

CHART No. 83.

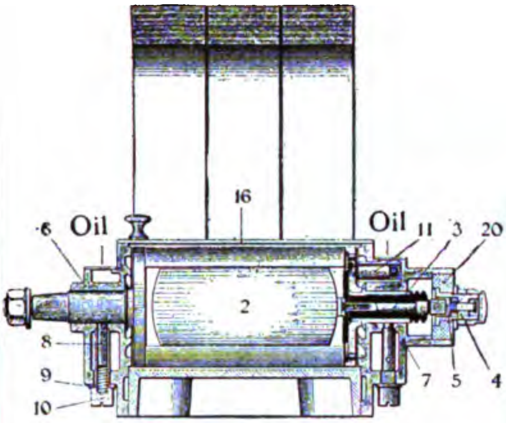


Fig. 1—Sectional View of a Low Tension Magneto with a plain bearing. Note the current is carried off from 4.

1—Double Magnet.
2—Armature.
3—Insulated bolt.
4—Terminal.
5—Terminal bolt with carbon.
6—Front end plate for wick lubrication.
6—Front end plate for ball race.
7—Rear end plate for wick lubrication.
8—Felt wick with spiral spring.

Explanation of Magneto Parts.

The terminal 5 is pressed against the bolt 3 by means of the spiral spring, both being carried by the insulated terminal 4, which is fixed to the steatite washer 20. The armature is carried by the two end plates 6 and 7. The lubrication is effected by the felt wicks 8 which pass through oil reservoirs cast on to the end plates. The carbon brush 11 effects the return of the current from the armature core to the magneto body, in order to prevent the current from going through and burning the bearings.

The current which is produced in the armature winding is carried from the terminal 4 by the insulated wire to the insulated pin of the sparking flange, and from here passes through the interrupter back to the motor frame, and thus to the magneto body, as long as the interrupter is in touch with the insulated pin. At the moment when the interrupter opens the contact, which is mechanically effected, the armature being in a certain position, a powerful spark is produced on the contacts, igniting the mixture.

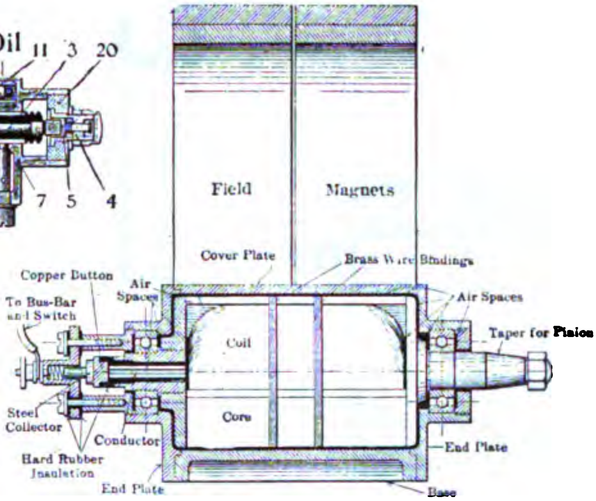


Fig. 2—Side Sectional View of a Low Tension Magneto with Ball Bearings.

Note how the current is conducted from the end of the armature shaft.

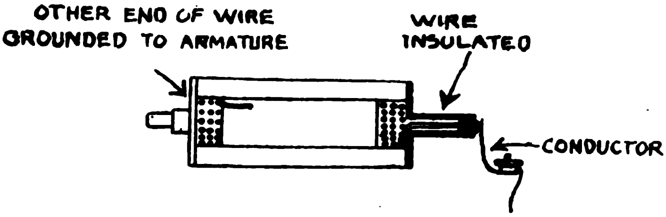


Fig. 3. Showing how one wire on ARMATURE is "grounded" and the other insulated.

One end of the wire wound around the armature connects with a spring on the end of the armature shaft but is insulated from the iron core of the armature.. This wire goes to the igniter or " contact breaker." The other end of the wire is "grounded" or fastened to the iron core of the armature.

CHART No. 84.

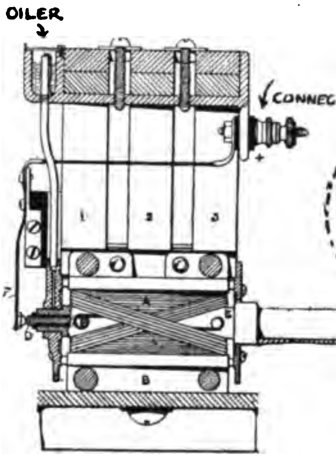


Fig. 1

Sectional View of a Low Tension Magneto Showing one method of conducting the current from the wire on the armature.

One end of wire A wrapped around the armature is grounded to the core of the armature at E. The other end is connected to an insulated conductor or collector D. The spring F carries the current from the terminal D to the binding post marked H, thence to the igniter.

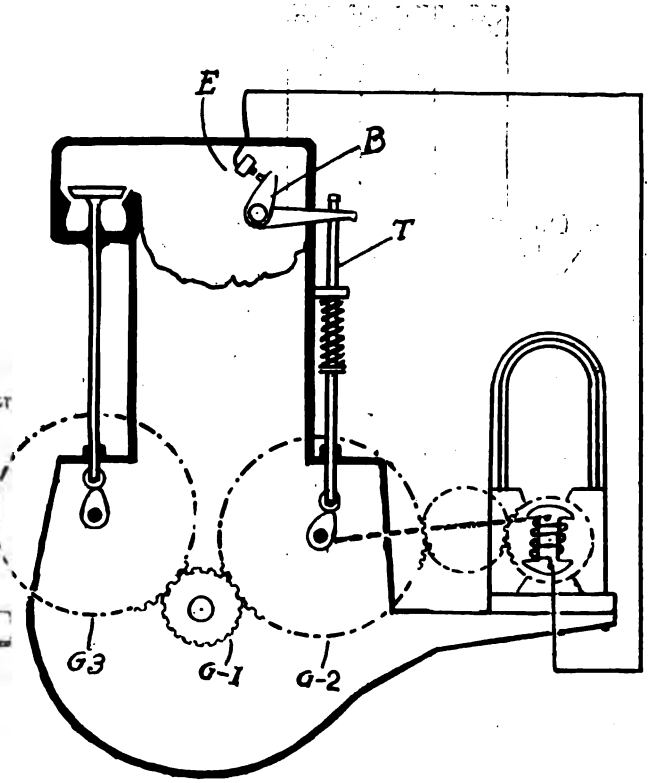


Fig. 2.

Illustration of a "Make and Break" System of Ignition with a Low Tension Magneto.

Note that the "Make and Break" derives its name from the "interrupter" arrangement which "makes and breaks" the circuit at a certain time.

The plunger rod is operated by a cam which is attached to a gear, driven by a gear on the crank shaft of the engine.

Names of Parts

E—Insulated Electrode.
B—The mechanical "make and break" electrode.
T—Tappet rod which is operated by the cam C.
C—Cam to operate the plunger rod.
G1—A gear attached to the crank shaft of the engine and which drives gear G2.
G2—A gear driven by gear G1 which operates the cam.

The Circuit

E is insulated from the engine.

B is grounded to the engine.

See figure 1, chart 86, showing how the current flows.

CHART No. 85.

INSTRUCTION No. 18.

LOW TENSION MAGNETO:—Construction. Low Tension Systems of Ignition. Low Tension Magneto and High Tension Coil.

The Structural Portion of the Magneto Consists of permanent magnets (Fig. 1 and 2, Chart 83) of V-shaped, generally called horse shoe magnets.

The Free Ends of the V-Shaped Magnets are known as the poles, one **North Pole** and the other the **South Pole.** To these poles are secured, to cast iron blocks, Fig. 5 (11a), known as "Pole Pieces" or "Pole Shoes."

The Magnets Are Then Fastened to a base of non-magnetic material (brass). The pole shoes are bored out cylindrically to receive the "Armature" (Fig. 2 and Fig. 4) which is of cylindrical form.

The Armature consists of an armature core of soft iron of H-shaped cross-section; also referred to as a "Shuttle" armature (Figs. 3 and 4). This core of soft iron serves to form a bridge for the magnetic flux between the pole shoes and also to carry the winding in which the current is induced.

The Armature Core is First Insulated with mica or similar material. Then it has several layers of heavy insulated wire wound upon it.

One End of This Wire is "Grounded" or fastened to the armature proper (Fig. 3, Chart 84). The other end goes through a "Collector" or brush and is conducted to the igniter by a wire.

The Armature is Revolved by being connected with the engine shaft, usually by two gear wheels, one on the engine shaft and one on the magneto.

The Electric Current is then taken from the binding post on the magneto to the igniter.

The Return Path of the Current is then through the engine, back through the base of the magneto to the ground connection or where the end of the wire wound on the armature is connected with the iron core of the armature. (See Fig. 1 and 2, Chart 85.)

The Current Generated by a Magneto is "Alternating," that is, instead of the current flowing from North to South pole or from Positive to Negative it is rapidly changed or alternated from one to the other, whereas the current of a battery or dynamo flows "Direct" or steady one way all the time.

For This Reason a Magneto is Not Suitable to Supply Current for a High Tension Coil With a Vibrator, but it supplies current for a High Tension Coil by use of a "Contact Breaker" and without a vibrator on the coil which will be explained further on.

TWO LOW TENSION MAGNETO SYSTEMS.

There are Two Methods for using a Low Tension Magneto for ignition.

One Method is to supply the electricity direct to the "Make and Break" igniters. (See Fig. 2, Chart 85.)

The Other Method is to supply the electric current in conjunction with a high tension or double wound coil (this will be explained later). (See Chart 82, Fig. 4 and 5.)

THE LOW TENSION MAGNETO AND A "MAKE AND BREAK" IGNITION SYSTEM.

As previously Stated on All Magnetos the Insulated Wire on the Soft Iron Core Is Wound Lengthwise, the inside end being securely fixed to the core itself, so as to be in metallic contact with the whole of the metal work of the machine.

The Finishing End of the Coil Connects Direct to a Carefully Insulated Terminal, (Fig. 1 Chart 85) by means of a spring-controlled carbon brush, so that a connection can be made to the sparking-plug of the engine.

The "Make and Break" Spark-Plug or Igniter as it is Often Called is an Important Part of the Low-Tension System, and entirely different from the simple porcelain or mica plug of the coil system.

It Consists of a Metal Pin Insulated With Mica (see Fig. 2, Chart 82) which projects into the combustion chamber of the engine; this pin is in direct contact with the armature coil previously mentioned.

A Metal Lever, Sometimes Called a "Hammer" or "Finger," in direct contact with the engine, is pivoted in such a way that it normally touches the inside end of the pin, this being effected by the stud which carries the finger having a spring-controlled device which keeps it pressed against the pin.

There is a Trigger or Striker Rod, so arranged that when the cam on the engine shaft comes round to a certain point it knocks the finger away from the insulated pin of the plug, and it will be observed that, as the magneto is also being worked from the engine shaft. it keeps in step with the actuating of the mechanical make-and-break.

The Function of the Make and Break Mechanism is to suddenly rupture the circuit of the armature coil in the magneto at the instant the current has reached maximum strength.

This Sudden Rupture of the Circuit causes the voltage of the induced current to rise considerably above its normal value. A flash simultaneously occurs between the insulated metal pin of the plug and the moving finger.

This Flash is of Quite a Different Character From the Spark Produced at the Points of an Ordinary High-Tension Spark Plug, being more of a flame which jumps across the space between the pin and the hammer.

When the Engine is Running at a Fair Speed this flame has intense heating effect, firing even a weak charge readily.

At Slow Speed It is Not So Strong, because the current induced in the armature becomes proportionately stronger as the speed of rotation increases.

The Rapidity of Actual Rupture of the Circuit is, of Course, Constant, as it is governed by a spring.

It is Possible to Advance and Retard the Time of Ignition through a certain range by having the interrupter rod so arranged that its position with relation to the notch in the cam may be altered.

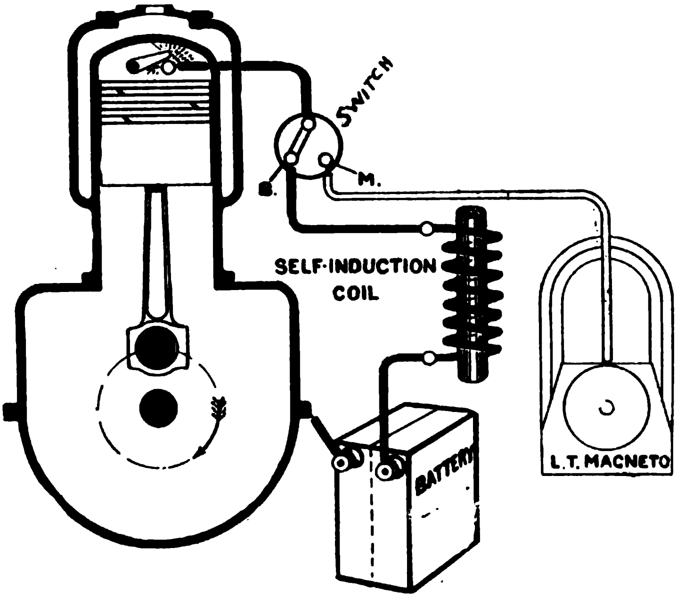


Fig. 1—A Low Tension "Make and Break" Ignition System using a Battery or a Magneto.

Note the battery current must run through a coil, whereas the low tension magneto current requires no coil—it's coil is the wire on its armature. This battery coil is a single wound primary coil.

When switch lever is on B the battery supplies the electricity. When on M the magneto supplies the electricity.

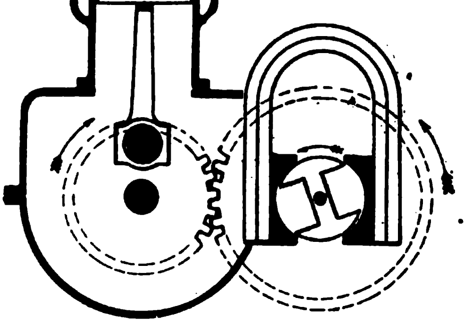


Fig. 2—Diagram Illustrating the principle of Timing a Low Tension Magneto

The armature is in one of the maximum positions just as the piston is completing the compression stroke and "break" mechanism has just tripped or broken circuit.

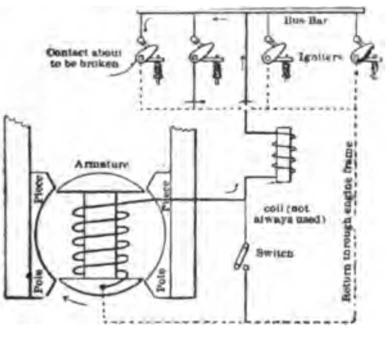


Fig. 3—Illustration Showing a "Make and Break" Ignition System on a Four Cylinder Engine

Note that a Bus Bar (large copper wire) carries the current to the insulated electrodes E. Note that a timing device is not needed as the cam on engine is timed to "trip" or "make and break" the ignition. See Fig. 3, Chart 82. A coil is shown but is not used if a magneto alone supplies the electric current. The coil is used when a battery supplies the current.

THE "MAKE AND BREAK" LOW-TENSION MAGNETO IGNITION FOR A MULTIPLE OF CYLINDERS

When Make and Break Ignition is Employed, the magneto is simplicity itself.

The Armature Has But One Winding of wire around it and induces a low-tension current only.

One End of the Coil is Grounded on the armature core, and the other is insulated and led out through the armature shaft to a rubbing-current collector outside. (See Fig. 3, Chart 82, also Fig. 3, Chart 86.)

The Current Induced by the Armature is Led Directly to a bus bar on the engine, making connection in multiple with all the igniters.

Each Igniter in Turn Makes Contact for a Short Arc of Crank Rotation and then breaks contact, producing a spark.

The Next Igniter Does Not Make Contact Till the first Has Broken.

To Shut Off the Sparks the Armature is Simply Short-Circuited by a suitable switch or push button.

It is a Peculiarity of All Magnetos that they can run short-circuited indefinitely without detriment, since the strength of the current is self-limited by local inductive action in the coil and core.

Illustration Fig. 3, Chart 82 shows a multiple cylinder engine with a low tension magneto as a generator of electricity, also a battery and low tension coil. This latter system is an auxiliary system.

In This System the current must pass through a single wound low tension coil.

A LOW TENSION MAGNETO AND BATTERY.

In Fig. 1, Chart 86, or in Fig. 3, Chart 82, Note that in this system of "Make or Break" ignition we have two sources of electric supply; either the Low Tension Magneto or the Battery.

If the Switch Is Thrown to "M" the magneto supplies the current.

If the Switch Is Thrown to "B" then the battery will supply the current.

When the Battery Is Used the current must flow through a single wound coil as shown.

When the Magneto Is Used, a coil is not necessary, as the winding on the armature of the Magneto acts instead.

TIMING THE LOW TENSION MAGNETO.

The Armature of the Magneto must be positively driven off the motor by means of chain or gear wheels. On motors with cranks at 180 degrees, where the ignition has to take place at 90 degrees relative to the camshaft, the armature has to be driven at crankshaft speed.

In the Low Tension System No Contact Breaker Is Fitted on the Magneto; a connection from the outer end of the armature winding joins up to the terminal of the hammer-break device inside the cylinder.

The General Practice When Timing (see Chart 86, Fig. 2) is to arrange for the mechanism of the break to "trip" when the piston is just completing the compression stroke or a little earlier; say 1/8 of an inch (or an amount determined by experiment to give the best results), the armature being, as in the case of the high-tension system, in "maximum" position.

No Variable Advance or Retardation is, as a rule, provided, reliance being placed on the proportionately greater volume or intensity of the spark as the speed increases, thus causing more rapid combustion.

The Factors to Be Determined in Timing With Low-Tension are the time of break, piston position and armature position.

SIMPLE METHOD TO AID IN SETTING.

The Former Can Be Very Accurately Set by the aid of an ordinary electric bell and battery, a simple circuit formed through the "break" device on engine.

When the Break Hammer Is in Contact with the insulated stud the bell will ring; but, on turning round the engine, the moment the circuit is broken between hammer and stud the bell will cease to ring.

If, as Should Be the Case, the fly-wheel is marked off to indicate piston positions, a very delicate adjustmnet can be made.

It Is Important in Adjusting the Hammer-Break to obtain a break of sufficient length, but not an excessive amount.

This Amount Varies according to the type of break mechanism used.

An Average Distance would be about 3-16ths inch, with a maximum distance of one-eighth between the hammer or tappet and insulated stud.

OBJECTIONS TO THE LOW-TENSION MAGNETO SYSTEM WITH "MAKE AND BREAK" IGNITERS.

We Have Learned How a Low-Tension Magneto Will Supply Current for a "make and break" system of ignition.

It Is Always Necessary to Crank an Engine Employing This System and sometimes necessary to "spin" the crank of engine, meaning that it must be turned quick and fast to generate enough electricity to ignite the charge to start the engine.

Objection to the Low Tension Coil or "Make and Break" System of Ignition is the arrangement for making and breaking the circuit inside of the cylinder. This method is usually accomplished mechanically, by a "snapping" process which causes considerable wear.

Another Objection is the speed of ignition—the method is slow in operation and does not act as quick in igniting the charge of gas as the jump spark.

A BETTER SYSTEM; USING A LOW-TENSION MAGNETO, IN CONJUNCTION WITH A JUMP SPARK (HIGH-TENSION) COIL.

By Referring to Fig. 1, Chart 87, and Figs. 4 and 5, Chart 82, we will observe that we are still using the Low-Tension (single wound) Magneto, but instead of taking the current direct to a "Make and Break" Igniter, we carry the current through an interupter (usually placed on end of armature shaft), thence through the primary winding of a double-wound (High-Tension) coil, thence to a spark plug which is screwed into the cylinder or cylinders.

But Observe Further that the current does not flow from magneto to the spark plug.

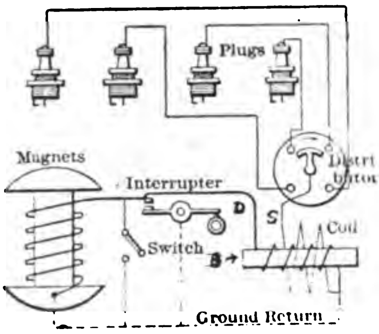


Fig. 1—Illustrating the Circuit or Wiring of a Low Tension Magneto with an Interrupter on the Armature Shaft and a Separate High Tension Jump Spark Coil. The interrupter is operated by a cam on the end of the armature shaft.

Fig. 2—Front view of a Low Tension Magneto with a Distributor. Also the "Make and Break" arrangement, called an "Interrupter," on the end of the Armature Shaft B.

This interrupter acts in place of the vibrator on the High Tension Coil (Double wound coil).

Explanation of Parts

B—A box or covering over the contact breaker. This box can be "advanced" or "retarded" just the same as a timer by connecting it with the spark lever.

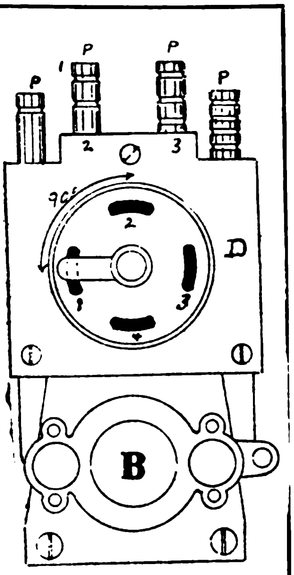


Fig: 2

P—Plug connections.

D—Distributor; distributes the secondary or high tension current from the coil to the spark plugs. Note the contacts 1, 2, 3 and 4. These contacts connect with connections P. When the brush is on 1, then No. 1 cylinder will fire; when on No. 2, No. 2 will fire, and so on.

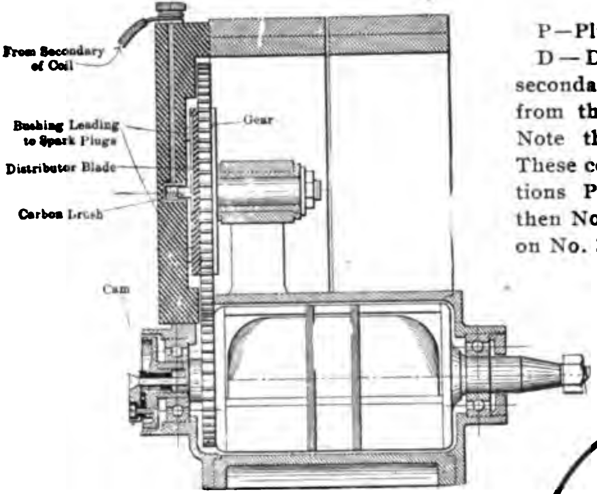


Fig. 3—Illustration Showing how the Distribution is Driven by a Gear on the Armature Shaft

It must be remembered that the Low Tension current is generated in the armature winding; it is then conducted to the "Primary" winding of the jump spark coil (a high tension coil without a vibrator.) The "Secondary" current from this coil is then distributed to the spark plugs through and by the distributor on the upper portion of the magneto.

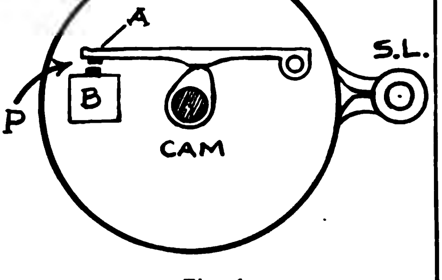


Fig. 4

Fig. 4—Illustration of Interrupter of End of Armature Shaft of Magneto.

When the cam on end of armature shaft revolves, the nose will raise the lever A, thereby breaking the contact of the platinum points P.

B is insulated from the frame of the magneto and end of the winding of wire on armature connects to same. Lever A is grounded to the frame.

The lever S.L. connects with the spark lever on steering wheel to "advance" or "retard" the time of ignition.

The nose on the cam is arranged according to the number of cylinders to be fired.

CHART No. 87

If You Will Take Your Pencil and Trace the Flow of Current from the magneto to the coil, you will note that the current flows only through the **Primary** winding of coil.

The Small Wire Wrapped Around This Primary Winding and Connected to Plug is insulated and has no metallic connection with the primary winding at all. It is called a **Secondary** wire.

The Current Is Induced From the Primary Winding to the Secondary winding.

One End of This Secondary (High-Tension) Wire connects with the spark plug and the other end is "grounded" to engine frame and flows back to the shell of the spark plug, then jumps across the points of the plugs.

In This Type the Armature Is Short-Circuited just before the spark is desired, breaking the armature short-circuit causes an extra current to flow through the primary winding of the induction coil

This Windng Has a High Resistance in order to compel the bulk of the armature current to flow through the short-circuit till the latter is broken.

A Mechanical Interrupter for Short-Circuiting the Armature at the Proper Time, is necessary.

THE INTERRUPTER OR CONTACT BREAKER.

The Interupter is Simply a Device for Making and Breaking the Armature Circuit, once for each explosion or twice per revolution and takes the place of both a Timer and a Vibrator as used on a regular high tension coil.

Interrupters are of Numerous Forms (See Fig. 4, Chart 87, also Fig. 1), but in all of them a pivoted lever carries a platinum contact point normally abutting against a platinum-tipped screw, and a moving cam striking the lever causes it to break contact. Frequently the cam is stationary, and the lever with its mounting revolves with the armature. The contact screw is insulated and current is led to it by an insulated screw or other conductor through the armature shaft.

Form of Interrupter as Shown in Fig. 1, Chart 87, giving an end view. It is attached to the end of the armature shaft. A spring holds the platinum points normally in contact, and they are separated by the cam.

This Interrupter Arrangement is also shown to good advantage in Fig. 2, Chart 96.

An Insulated Contact leads the momentary extra current to the primary winding of the outsde spark coil, the other terminal of the coil being grounded.

To Cut Off the Spark the coil is short-circuited. (See switch, Fig. 1, Chart 87, also Fig. 4 and 5, Chart 82.)

HIGH TENSION DISTRIBUTOR.

A High Tension Distributor whereby the secondary current from the coil is delivered to the spark plugs in order, is also necessary. The distributor for a 4-cycle engine is driven from the armature by gearing with two to one reduction. (See Fig. 1, 2 and 3, Chart 87.)

In This Diagram is shown the distributor as arranged for a 4-cylinder engine.

The Secondary Current from the coil is led to a revolving arm which delivers current successively to the four different spark-plug cables.

The Distributor is Necessarily Geared to Run at Half the Speed of the Armature and Interrupter, since it supplies the four cylinders only once in two revolutions.

OBJECTION TO THIS SYSTEM JUST MENTIONED.

Is That We Have No Means For Starting the Engine except to crank it.

If We Would Add a High Tension Coil With a Vibrator and a Separate Battery, using this system to start the engine with and then switch over to the magneto, which would then supply the current instead of the battery, it would overcome the objectional starting feature.

It Would Not Be Necessary Then to "Spin" the Armature Shaft on magneto in order to make it generate electricity.

It Would Be Easier to Start With a Vibrator Coil and Battery because the vibrator on coil begins to buzz and a spark is made the moment the timer makes contact.

With This Coil and Battery it Is Often Possible to Start the Engine on Compression; meaning that if there is a charge in either cylinder the charge can be ignited by shifting the spark lever, which will start the vibrator on coil and spark cylinder which often happens.

THE PACKARD SYSTEM OF IGNITION.

This System That Will Exemplify the system of a low tension magneto and a high tension coil and battery for starting. (See Chart No. 87A.)

PACKARD COIL BOX.

The Box in the Center of the Dash Contains Two Coils, a switch and a lock. Each coil as made is a complete unit in itself, and each may be lifted out for inspection, test, or repairs without disturbing any other part.

The Right Hand Coil is for Battery Current, and is fitted with a single vibrator. The left hand coil is for magneto current, and has no vibrator.

SWITCH.

The Switch Has Three Positions.. Turn to the right for battery, turn to the left for magneto current, and turn to a vertical position for neutral (no current).

BINDING POST.

On the Under Side of the Coil are Four Binding Posts:

P. P. brings low tension current from the battery.

P. R. brings low tension current from the magneto.

B. transmits high tension current from both systems.

P. M. is a common ground wire for both kinds of current from both systems.

The Low Tension Current From Both the Battery and Magneto, though of good amperage (volume), are low in voltage. The two coils receive from the battery or magneto their respective low tension currents and deliver currents of high tension, suitable for gas engine ignition.

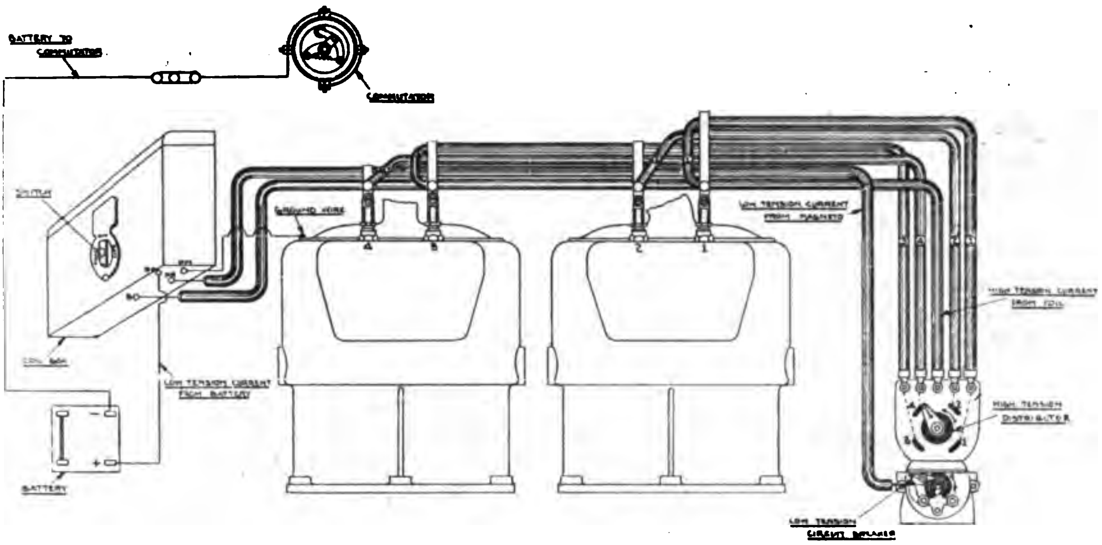

BATTERY TO COMMUTATOR
COMMUTATOR
SWITCH
GROUND WIRE
COIL BOX
LOW TENSION CURRENT FROM BATTERY
BATTERY
4
3
2
1
LOW TENSION CURRENT FROM MAGNETO
HIGH TENSION CURRENT FROM COIL
HIGH TENSION DISTRIBUTOR
LOW TENSION CIRCUIT BREAKER

Fig. 1. The Packard System of "Dual Ignition."

First System: Low tension magneto with a separate, double wound high tension coil, without vibrator.

Second System: Battery, timer and high tension coil with vibrator. Distributor is mounted on the upper portion of the low tension magneto but distributes the current for both the Magneto System and the Coil and Battery System.

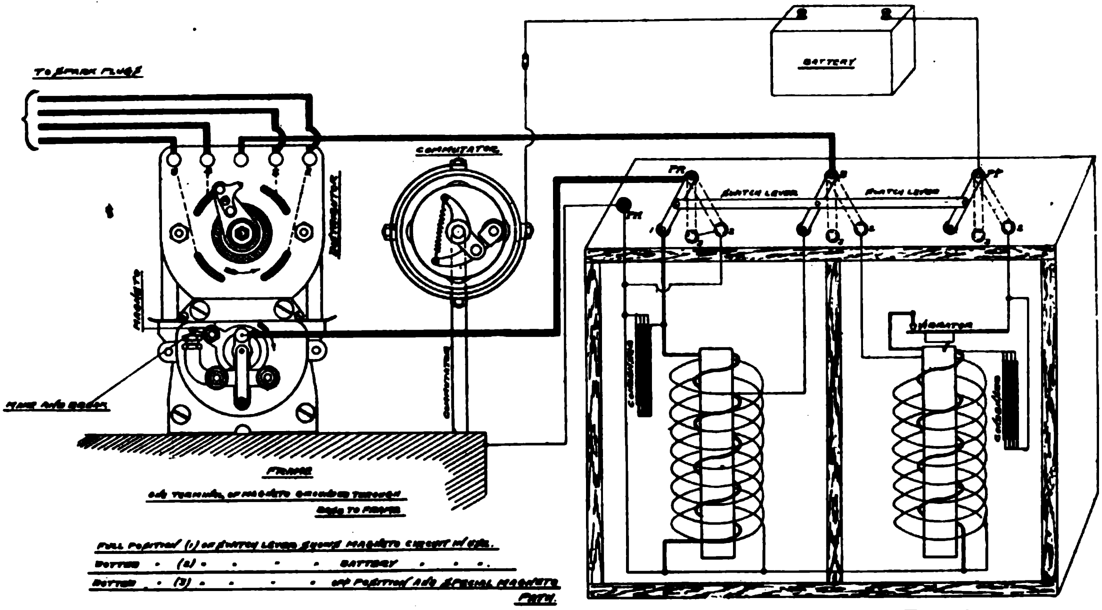

TO SPARK PLUGS
DISTRIBUTOR
MAGNETO
COMMUTATOR
MAKE AND BREAK
FRAME
ONE TERMINAL OF MAGNETO GROUNDED THROUGH BASE TO FRAME
FULL POSITION (1) OF SWITCH LEVER SHOWS MAGNETO CIRCUIT IN USE.
DOTTED (2) BATTERY
DOTTED (3) OFF POSITION AND SPECIAL MAGNETO PATH.
BATTERY
FR
FM
SWITCH LEVER
SWITCH LEVER
1
2
3
CONDENSER
VIBRATOR
CONDENSER

Fig. 3. Fig. 4.

Fig. 5. The Packard Diagram of Wiring.

CHART No. 87A

BATTERY WIRING.

Commencing at the Positive Pole of the Battery (red and marked (+), the current follows the connecting wire to the post on the under of the coil marked P. P. At this point it enters and passes through the primary winding of the right hand or vibrator coil, coming out again at post marked P. M. and along the connecting wire to the screw on the motor where it is grounded.

The Only Path By Which It Can Return to the Battery is through the contact shaft, and roller to one of the binding posts, and by means of the metal connecting strap to the wire running to the negative terminal, the circuit being completed each time the roller in the contact box passes over one of the metal contact pieces.

HIGH TENSION CURRENT.

Whenever This Low Tension Circuit From the Battery Is Completed, as above described, a high tension circuit is induced in the secondary winding of the battery coil. This current leaves the coil at post "B" to the central post at the top of the square distributing plate on the magneto.

From Here It Passes Along a Wire Embedded in the Plate to a continuous copper ring in the outer face of the plate. From here it is taken up by a carbon contact piece midway the length of the rotating arm. This contact piece is held by a light coil spring in contact with the ring mentioned.

The Current Now Passes to a Metallic Contact Piece at the Outer End of the Rotating Arm, which is held by a coil spring into contact with the face of the plate. Embedded in the face of the plate are four brass segmental pieces which are connected by means of wires running through the plate to four binding posts at the top of the plate. The current passes in turn from the metallic contact plunger to each of these four segmental contact pieces as the distributor arm rotates, and from these segmental plates to the four binding posts, and then through the connecting wires and spark plugs to the "ground" and back again to the battery coil, through the binding post P. M. on the coil box.

BATTERY CURRENT.

The Battery Current is Generated By Chemical Action, and is ready to flow the instant its circuit is completed. It is therefore particularly useful for starting "on the switch." It is only necessary to break the circuit to stop the flow of the current. Batteries require frequent recharging and occasional renewals.

VIBRATOR ADJUSTMENT.

The Vibrator Operates Only When the low tension current is passing through the primary winding of the battery coil. It is adjusted by means of a screw and lock-nut. If too tight or too loose, the results may not be satisfactory. Too tight an adjustment is not economical. A medium adjustment is best. A good plan for adjustment is to turn up on the thumb screw at the loose end of the vibrator, then adjust the spring so the distance between it and the top of the coil will be about 1-16 of an inch, and screw down on the adjusting screw until a medium toned buzz is obtained.

THE PACKARD MAGNETO CURRENT.

The Magneto Current is the Result of Magnetic Induction and is practically inexhaustible. The magneto only generates current when its armature is being revolved, either by turning the starting crank or by running the motor.

The Low Tension Current from the magneto enters the primary winding of the magneto coil at the post P. R. and leaves it at post P. M., returning to the magneto through the "ground."

You Will Readily See what an important part the wire connecting post P. M. with the screw on the rear cylinder has to perform. It is the common path for all of the current of both systems. Its connections must be well made and clean.

The High Tension Current thus induced in the secondary winding of the magneto coil follows exactly the same path as described in connection with the high tension battery current from post "B" through the distributor arm and plate of the magneto to the respective spark plugs, and back again to the magneto coil through the "ground" and post P. M.

Whenever the Motor is Running, the magneto is developing current. It only passes through the magneto coil, however, when the switch is thrown to "Mag." With the switch in any other position, the current is grounded without passing through the primary winding.

MAGNETO INTERRUPTER.

The Interrupter Mechanism of the magneto is located at the rear end of the armature shaft, and is protected by an aluminum cover. This mechanism should be kept clean and the contact points flat and parallel with each other, and adjusted so as to open 1-64 in., when breaking the circuit. Ordinarily they can be cleaned by inserting a piece of paper between them and drawing it about. If these points become pitted they should be dressed down by drawing an exceedingly fine thin file between them.

To Adjust These Points Retard the Spark to Its Limit, and in order to make certain that this is done, with the hand press the plate which supports this mechanism down to its lowest possible point, so as to take up all slack in various spark levers and connections. Then rotate the armature shaft until the little groove marking on the edge of the cam which operates the make and break lever comes precisely opposite the little pointed stud in the face of the plate; then adjust the anvil (or fixed point), of the make and break device, so that the points will begin to separate as the marking groove passes the pointed stud.

CARBON BRUSH.

A Carbon Brush is held in contact with the rear end of the armature shaft by a flat spring. This contact should be kept clean and free from oil. A simple and effective method is by passing a slip of paper between the two and moving the paper about.

The Splitdorf "Double" System of Low Tension Magneto and High Tension Coil.

This system consists of two independent systems — First; low tension magneto, non-vibrating high tension coil. Second—High tension coil with vibrator and battery and a separate distributor and timer (made in one). This distributor-timer is run from usual cam shaft.

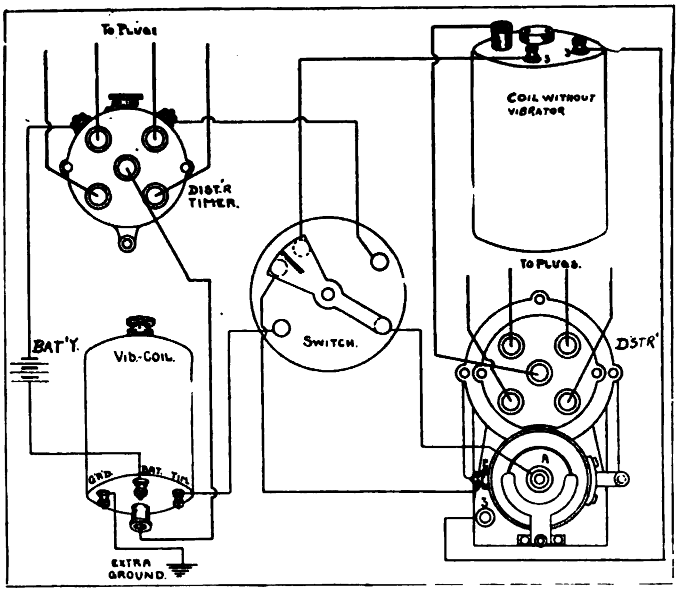


Fig. 1—Splitdorf "Double" System with a Low Tension Magneto.

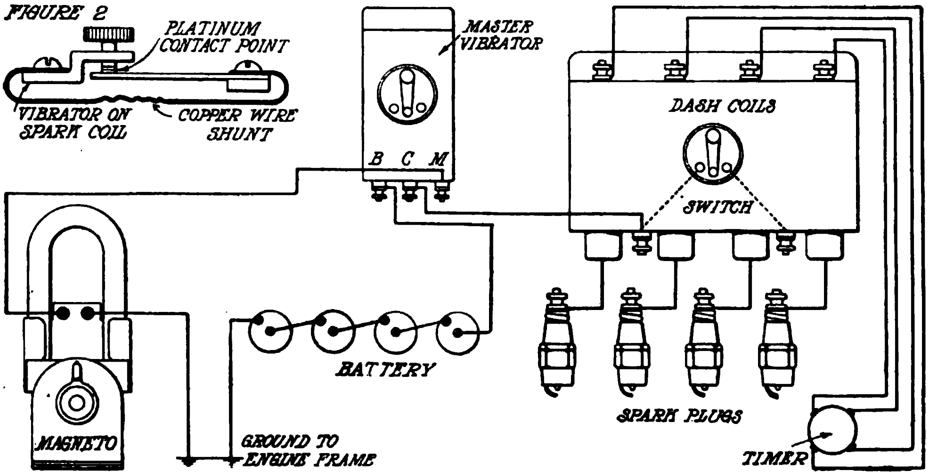


Fig. 2A.—The K. W. Low Tension Magneto with a Master Vibrator Coil.—This one coil vibrates for all.

This system consists of simply adding to a regular high tension coil and battery system, a low tension magneto to generate the current and a master vibrator coil to do the vibrating instead of the vibrators on the several coils.

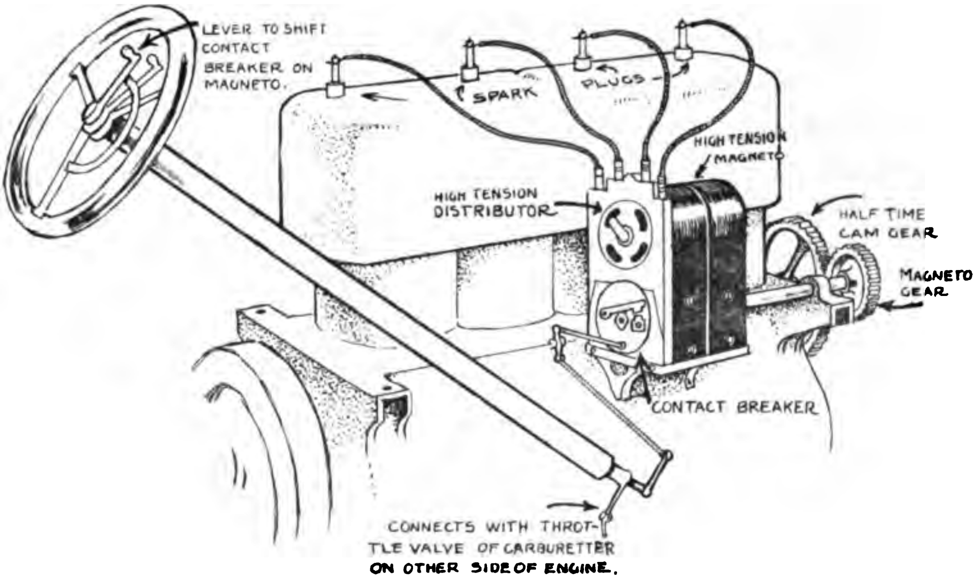
A good way to explain this system would be to imagine we had a four cylinder engine using a four cylinder high tension coil and a battery.

Now by placing this K. W. Magneto on car so that it will be run by the engine, then place the K. W. Master Vibrator Coil on the dash alongside of the four cylinder coil and connect up as shown and not failing to screw down all the vibrator screws or short circuit them as shown in lower part of illustration of Fig. 2, the results will be as follows:

To start engine switch the switch lever on Master Vibrator to Battery or "B".

After engine is running switch the switch lever on Master Vibrator to Magneto or "M."

A careful study of the drawing will make the principle of this system clear. Also see illustration, Chart 75, which will explain the system as it is used with battery alone.


LEVER TO SHIFT CONTACT BREAKER ON MAGNETO.
SPARK
PLUGS
HIGH TENSION MAGNETO
HIGH TENSION DISTRIBUTOR
HALF TIME CAM GEAR
MAGNETO GEAR
CONTACT BREAKER
CONNECTS WITH THROTTLE VALVE OF CARBURETTER ON OTHER SIDE OF ENGINE.

A High Tension Magneto System.

Attaching a Magneto: The base of magneto is grounded to engine—and is usually attached to the engine.

Driving a Magneto: Usually driven by gears. Belt or chain would not do because the armature would be thrown out of gear by slack in the chain or slipping.

Wiring a Mganeto: Heavy cables must be used.

Timing a Magneto: The armature must be set in a certain position, similar to setting a timer.

Advancing and Retarding the Spark of a Magneto. The contact breaker is connected to the spark lever on the steering wheel just the same as a timer is connected.

A "Dual" System of Ignition with a High Tension Magneto: Consists of a magneto (high tension) and a high tension coil and battery system, both independent of the other but both systems using one set of spark plugs.

A "Double" System of Ignition with a High Tension Magneto: Consists of two independent systems of ignition, each system using a separate set of spark plugs.

CHART No. 88A

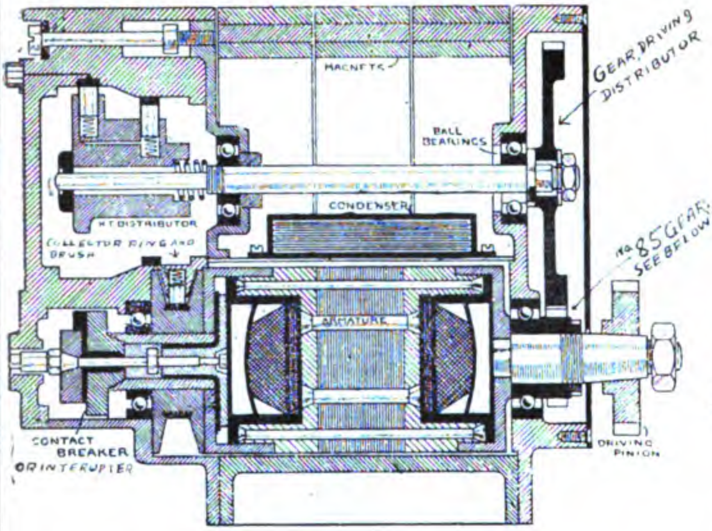


Fig. 1—Sectional View of a High Tension Magneto

Note the double wound armature. The primary winding is the same as in the low tension magneto, but instead of only one winding on the armature, a second or secondary winding is wound over the primary winding. With this arrangement of winding, the coil is dispensed with and instead of the magneto delivering a low tension or low voltage, it delivers a high tension or high voltage.

The distributor is driven by a gear at the drive end of the magneto. *The distributor is placed on the front of the magneto as shown in Figs. 1 and 2 and is driven by gears on rear of magneto as shown in Fig. 1.

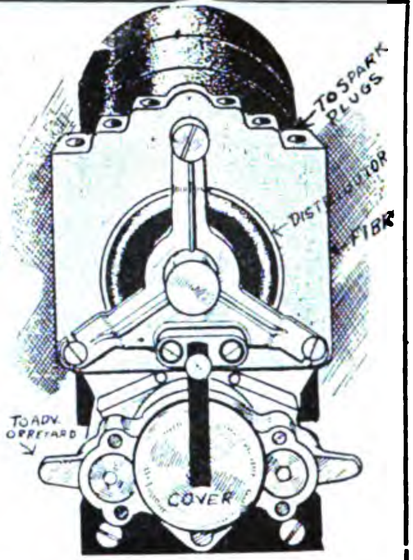


Fig. 2—End view of a High Tension Magneto with the Contact Breaker or Interrupter Enclosed

The Distributor is also enclosed.

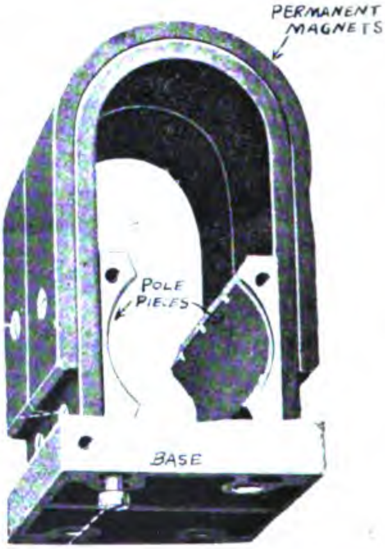


Fig. 3—The Horse Shoe Magnets, Pole Pieces, etc. are just the same as used in a Low Tension Magneto.

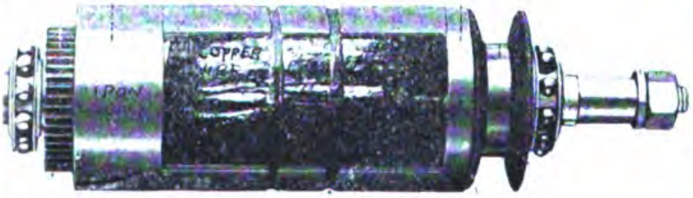
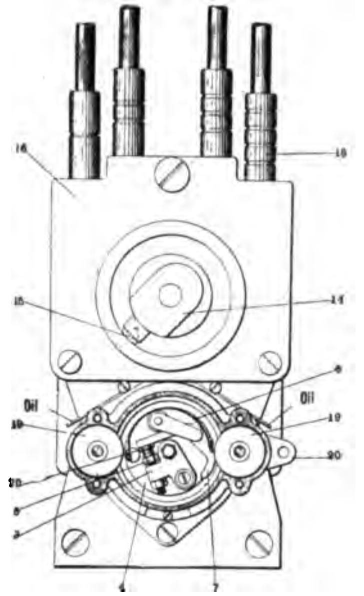


Fig. 4—The Armature is Just the same as used in a Low Tension Magneto, with the exception of there being another winding of fine wire over the primary winding.

One end shows the gear, driven from engine shaft.
The other end shows the "Collector Ring."

---

*See Dyke's working model of magneto.



Fig, 1. End View of a Bosch Magneto

Showing the arrangement of the Interrupter or Contact Breaker and Distributor.

Names of the Parts. See Figs. 1 & 3

1—Brass plate.
2—Contact-breaker screw.
3—Platinum screw block.
4—Contact-breaker disc.
5—Long platinum screw.
6—Contact-breaker screw.
7—Contact-breaker lever.
8—Condenser.
9—Slip ring.
10—Carbon brush.
11—Carbon holder.
12—Connecting bridge.
13—Contact carbon.
14 - Rotating distributor piece.
15—Distributor carbon.
16—Distributor disc, (hard rubber)
17—Metallic segments.
18—Contact plug.
19—Fibre roller.
20—Timing lever.
21—Dust cover.
22—Cover.
23—Triangular clamp.
24—Nut for switch wire, (short circuit)
25—Spring for fastening brass cap.
26—Brass cap.
27—Brass block for fastening spring of brass cap.
28—Fixing bolt.
29—Short platinum screw.
30—Stop screw for timing lever.

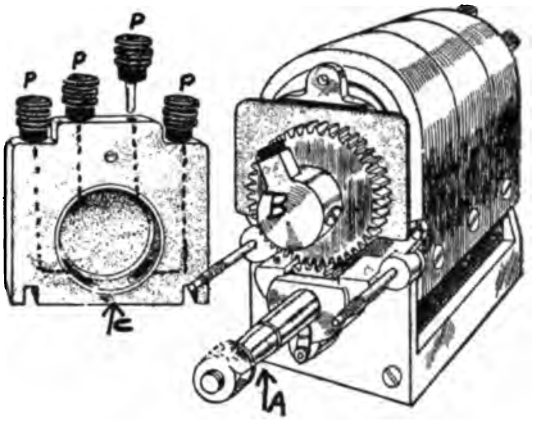


Fig. 2—An Exaggerated View of the Distributor of a High Tension Magneto

Sometimes the gear is in front and sometimes in the rear.

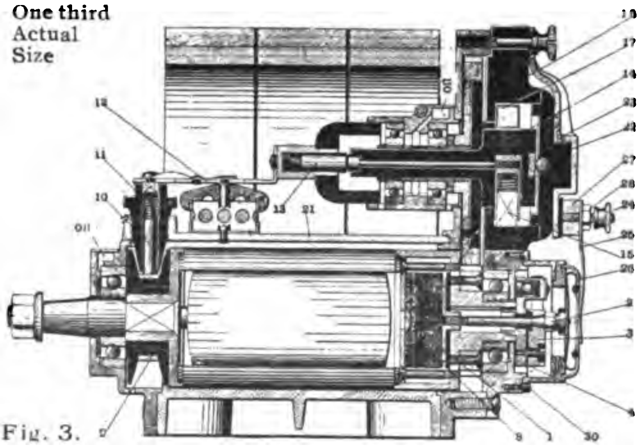
The cover being removed. The two-to-one gear drive from armature is shown, and the rotating arm carrying a carbon "brush" which presses against the metal sector pieces visible in circular recess of cover. The distributor arm revolves at half the speed of the armature, the four contacts being completed in two revolutions of armature, which equals two revolutions of a four-cylinder engine. The detachable plugs for the cable connection are shown.

A—Armature Shaft (Contact or breaker box removed).

B—Brush holder—Note the carbon brush in end of same.

C—Is the "collector" for the distributor. The metal sectors are shown connected by dotted lines to the terminals P.

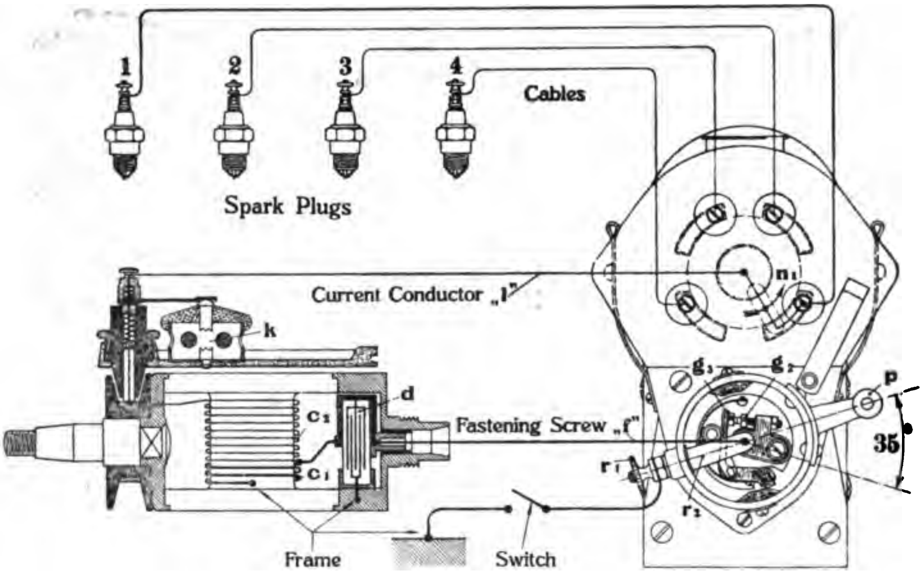
P—From the terminals P the large secondary wires extend to the spark plugs.



One third Actual Size

Fig. 3.

CHART No. 90.



Description of Diagram of Wiring of Bosch High Tension (DU4)Magneto With Double Wound Armature,

Between the pole shoes of two steel magnets which form a strong magnetic field, a so-called shuttle armature rotates. By this motion a current is produced in the armature which reaches its maximum twice in one revolution, i. e. at each 180° of rotation, therefore a spark can be produced at each half revolution of the armature.

The armature is wound in two parts, one being the continuation of the other and of which the inner winding C1 is the primary, consisting of a few turns of heavy wire and the other the secondary C2 consisting of many turns of fine wire.

The current is produced in the primary winding by the rotation of the armature and by the interruption of the primary circuit by means of a contact breaker a high tension current is induced in the secondary winding, which, at the moment of breaking the contacts g2 g3 causes a spark to jump across the electrodes of the spark plug, and fires a cylinder of the engine according to the position of the brush on the high tension distributor.

As the arc-like spark can only be produced when the armature is in a certain position, and as the ignition has to take place at a certain period in the movement of the piston, it is necessary that the armature is positively driven at the same speed as the engine. The gear wheel which carries the distributor carbon brush N1 is so arranged that it revolves at the same speed as the cam-shaft of the motor. The variation of the time of ignition is effected on the magneto itself by means of the timing lever p causing the interruption of the primary current to take place earlier or later.

The Arc Light system of ignition may be cut off by permanently short circuiting the primary circut. This is accomplished by an insulated wire connected from the nut rl to the switch, the other pole of the latter being connected to the motor frame. As soon as the switch is closed the current passes over the contact rl, contact spring r2 and screw f and the action of the contact breaker is futile.

In order te protect the insulation of the armature and of the current conducting parts of the apparatus against excessive voltage a safety spark gap k is arranged on the dust cover. The current will pass through this gap in case a cable is taken off while the magneto is in operation or if the electrodes on the spark plug are too far apart.

The front and rear armature spindle are fitted with ball bearings. The distributor spindle however has a slide bearing with wick lubrication. The other parts of the magneto require no lubrication, and it is especially pointed out that the contact breaker is so designed as to work without oil. This renders it impossible for oil to reach the contact surfaces while the device is in operation.

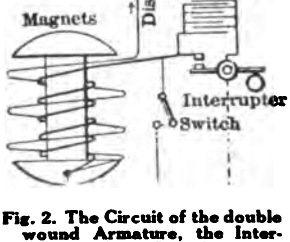


Fig. 2. The Circuit of the double wound Armature, the Interrupter and the Switch.

CHART No. 91.

INSTRUCTION No. 19.

THE HIGH TENSION MAGNETO:—Construction, Principle and Wiring of the High Tension Magneto. Timing and Setting the Magneto.

EXPLANATION OF THE HIGH TENSION SYSTEM WITH DOUBLE WOUND ARMATURE.

This Type of Magneto is distinguished by two particulars:

First, the High Tension Winding, instead of being applied to a separate coil, is wound over the primary coil on the armature itself. (See Fig. 2, Chart 91.)

It is Carefully Insulated from the primary except at one end, where both it and the primary coil are grounded on the armature core.

The Other End is led carefully insulated to a collector ring mounted on the armature shaft, and a carbon pencil rubbing on this collector ring takes off the secondary current and leads it to the distributor. (See Chart 90, Fig. 3 (10), also Chart 91, Fig. 1.)

The Other Respect in Which This Type Differs is that a condenser is employed in connection with the interrupter to suppress the extra current. (See explanation of a "Condenser," Fig. 10, Chart 75B.)

Owing to the Fact That the Secondary Coil of the High Tension Magneto is located on the Armature Itself it follows that it not only receives an induced current, due to the breakage of the primary current, but itself induces a current like that of the primary coil, but smaller in volume.

It Has the Same Form of Armature, field magneto, and interrupter, as that in Chart 83. The armature-coil, however, is different, having a small primary winding with a heavy secondary winding outside of it.

The High Tension Magneto Contains Another Feature, namely, the high tension collector ring. (Fig. 1, Chart 89.)

The Condenser is Usually, though not necessarily, located on the armature shaft in order to get it as close to the interrupter as possible, and it is there shown in Fig. 1, Chart 91—"d."

In Some Magnetos, for the sake of greater accessibility and other reasons, the condenser is located outside the armature in a stationary sealed box.

HIGH TENSION COLLECTOR RING.

The High Tension Collector Ring performs for the high tension current the same function that the copper button at the end of the armature shaft in Fig. 1, Chart 85, does for a low tension current. That is to say, it permits the high tension current to be taken off and led to the distributor.

The Collector Ring is of Hard Rubber with a brass ferrule surrounding it, against which ferrule a heavily insulated stationary carbon pencil bears. The hard rubber spool has wide flanges for the purpose of preventing the high tension current from escaping, by giving it a long path to travel from the brass contact ring to the shaft. As hard rubber is much more resistant than air the current tends to travel over the surface of the spool instead of striking through it.

From the Carbon Collector Brush the Current is Led Through a Suitable Conductor to the Center of the Rotating Portion of the Distributor, see Fig. 1, Chart 91—in this case through a spring and a carbon pencil projecting from the distributor shaft, which is hard rubber with a metal sleeve over it for bearing purposes.

DISTRIBUTOR.

Instead of the Flat Distributor Blade of Fig. 2, Chart 87, we have a carbon distributor brush, "B" (Chart 90, Fig. 2) pressed radially outward by a spring and running against the inner surface of a hard rubber ring, "C", in which are inlaid the contact segments from which the current goes through suitable terminals to the spark plugs at "P."

CONSTRUCTION OF THE "DOUBLE-WINDING" ARMATURE TYPE MAGNETO.

In Any Standard Magneto made on this principle the general construction would be as follows:—The field magnets consist of two—or usually three—pairs, one magnet of each pair being superimposed above the others. (See Fig. 3, Chart 89.)

In Some Few Cases three magnets are placed one over the other. The magnets are set to give correct north and south polarity.

The Ends or Poles embrace "pole pieces" of soft iron, bored out to allow the armature to rotate quite freely, but very closely to the pole faces; in some cases the clearance is only .002 inch.

The Armature Is, in practically every standard type, of the well-known "shuttle" section.

The Best Class Machines have the armature built up of thin stampings of soft iron, each insulated from the other by a thin film of varnish.

This Form of Construction is Known as a "Laminated Armature Core.". A laminated armature core is shown in Fig. 3, Chart 83, and a complete armature wound with double winding is shown in Fig. 4, Chart 89.

It Has the Advantage over a solid cast-iron core in that the electrical efficiency is higher through the absence of "eddy" currents in the iron core, which represents considerable waste of energy and causing heating.

By Breaking Up the Core Into Thin Sections, the currents cannot circulate through the iron.

In the Case of a Solid Core, the iron would be annealed to render it as "soft" as possible, to obtain the best magnetic effect.

To the Ends of the Armature the steel shaft or spindle is fixed by brass end plates. (See Fig. 3, Chart 83.)

One End of the Shaft is Hollow, and it is noteworthy that practically all machines are fitted with ball bearings to eliminate friction and wear.

The Armature Core is insulated with varnished tape, and then the "primary" winding of thick, insulated wire carefully wound on.

The Beginning of the Winding is connected direct to the core, or, as it is usually termed "grounded." (Fig. 2, Chart 91.)

The Finishing End is passed down through an insulating bush into the hollow shaft.

This Winding is Very Carefully Insulated, and then over it is wound the "secondary" winding, composed of a great quantity of fine gauge wire, insulated with silk and soaked in paraffin wax.

The Beginning of This Winding Joins to the end of the primary.

The Finishing End is also taken through the center of the shaft through an ebonite tube.

The Primary Now Makes a Connection With the Interrupter Device, or "make and break," in principle little different to the positive make and break used in battery and coil ignition.

HIGH TENSION DISTRIBUTOR CONNECTIONS.

The Secondary or High Tension End of the Windings makes a connection with the distributor. (See Fig. 1, Chart 91.)

There Are Numerous Methods of Making the Connections; usually a carbon brush pressing on an insulated ring is adopted, thus allowing the armature to rotate freely, and also enable the induced current to be drawn off. (See Fig. 3, Chart 90.) (See 10-11-13.)

The Distributor Is, in Effect, a Rotary Switch, specially insulated and provided with a number of contacts equivalent to the number of cylinders on the engine. (Fig. 2, Chart 90.))

THE CONDENSER—ITS PURPOSE AND PLACE.

An Important Detail in all high tension magnetos is the condenser built up of a large number of paraffined paper or thin mica sheets, interleaved with tinfoil. (See Fig. 1, Chart 91-d.)

It Is Made Up Into a Compact Block, and connected in such a way that it forms, in effect, two large sheets of tinfoil separated with the insulating paper.

On Many Machines the Condenser is Fitted in a Small Detachable Case, so that if it should "short circuit" it can be quickly replaced. One sheet is "earthed" and the other joins to the insulated end of the primary winding.

A Current is Induced in the Primary Winding when the armature is cutting the greatest number of lines of force.

The Winding is at This Moment a Closed Circuit, but just on the point of being opened by the cam striking the "make-and-break."

This Sudden Interruption of the Circuit at the Instant of Maximum Induction induces a high-voltage current into the secondary winding. It is at the moment of interruption of the circuit that the condenser comes into action by allowing the charge in the primary winding to expend itself quickly.

In a Sense it is a similar action to a spring taking up a sudden mechanical shock.

If the Condenser is Properly Made and proportioned, there will be little or no sparking between the platinums, and the circuit will be completely and instantaneously interrupted. Without a condenser heavy sparking would occur, and the "break" would be delayed, and the high-tension current seriously weakened.

GENERAL EXPLANATION.

A Current is Induced Twice Per Revolution, and the distributor is geared proportionately with the armature to give the correct number of sparks according to the number of cylinders the engine is provided with.

The Timing of the Ignition Moment relative to the piston position is not such a simple and straightforward matter in the case of magneto as with coil and battery.

As Before Explained, there is a particular position during the rotation of the armature between the poles of the magnets when the induction of current will be at a maximum value; the moment of interruption of the primary circuit should therefore synchronise with it.

If the Timing is Required to be Made Later, and the contact make-and-break moved bodily through so many degrees of angular movement, it must follow that the armature will have moved past its best position for induction into a less favorable one.

By Using a Very Powerful Set of Magnets, however, it is possible to compensate for this disadvantage.

Another Method is based on the fact that the strength of the induced current is proportional to the speed of rotation. If, now, the period of "maximum" induction is made to synchronise with maximum retardation, the current will be at a comparatively high value, even when the speed is low, so that it is possible to start on the magneto.

When Advancing the Ignition, although the armature is at a less favorable position, the speed will be higher than before and compensation thus obtained.

THE SAFETY SPARK GAP.

Mention May Be Made here of a device known as the safety spark gap, fitted to machines of the double-winding type, purposely to prevent the armature winding being subjected to undue strain, either by the machine being driven at an excessive speed, or owing to the secondary discharge gap across the plug points being too wide.

The Safety Gap, see illustration in Chart 91, Fig. 1, forms a discharge point set to a predetermined distance from the frame, this point being in direct connection with the high-tension terminal.

The Winding Can Therefore safely discharge if the normal path is cut off.

TO SWITCH OFF THE CURRENT.

From a Magneto the method is the reverse of a coil and battery.

Instead of Breaking the Circuit the switch closes it, that is closes the armature circuit by temporarily placing the end of the primary winding to the frame.

Thus No Interrption Occurs when the interrupter device acts, and no high voltage is generated in the secondary.

An Alternative Way of Stopping the Sparking at the Plug Points is to use a cut-out switch on the plug, and put the high-tension winding temporarily to frame.

This Method is Convenient for testing the sparking of individual cylinders.

Most Magneto Systems have some provision for dual ignition, so that, either in conjunction with a special trembler coil or some modification of the armature windings and contact maker, current can be utilized from an accumulator and the high-tension worked off the one distributor.

By Means of the First Arrangement closing a switch momentarily will usually cause the engine to start.

If Only the Armature Windings are Used and current sent through them, a partial turn of the armature would be required to operate the make-and-break.

Without Assistance from the battery, the magneto may be required to be turned fairly fast to start the engine.

SPARKING PLUGS FOR USE WITH MAGNETOS.

There are a Number of Specially-Designed Plugs for use with high-tension magnetos. The insulation is either porcelain, steatite (soapstone), or mica.

The Sparking Electrodes are considerably stouter than is usual for coil and battery ignition, and are made of nickel, or other metal with a high fusing point, such as platinum or iridium.

The Heating Power of the Magneto Spark, especially when the machine is driven fast, is very intense, so that it is necessary that the sparking points or electrodes should be sufficiently heavy not to fuse or become incandescent, and thus probably cause pre-ignition.

About 1-64 inch is correct distance to set magneto spark plug points. If too great a gap is allowed the spark will jump at the "safety gap" instead of the plug.

A Magneto Type of Spark Plug is shown in Chart 72.

RATIO OF ARMATURE SPEED TO ENGINE SPEED.

With Few Exceptions, all magneto machines are positively driven.

The Exceptions Need Not Necessarily Be Driven By Gear Wheels or chains, as the purpose of the machine being to maintain a condenser in a charged condition, the driving may be effected by a belt or friction wheel.

The Synchronizing has to be done at the positively driven contact maker, which discharges the condenser current into an induction coil at the desired instant and produces the spark.

Machines Operating on This Principle must be geared to run at a high speed, from three to four times that of the engine.

All Standard Types of Magnetos Must Be Positively Driven, because the armature movement and break of circuit at the platinum contacts must synchronize with the firing position of the piston.

Taking a Typical Example of High-Tension Magneto, the ratios of armature speed would be as follows:

Engine, No. of Cylinders	Rev. of Magneto	to Engine Crankshaft
1	1	2
2	1	1
3	3	4
4	1	1
6	3	2
8	2	1

One Type of Magneto, still used to some extent, is exceptional in having four maximum positions, one at each 90 degrees.

The Armature Itself is Stationary, and induction occurs from the rotation of a soft iron sleeve between the poles of the magnets and the armature.

This Machine has to be driven at the same speed as the camshaft.

The Reasoning on Which the Speed Ratio of Armature is Based is Simple to Follow, knowing that there are two currents produced per revolution in practically all types, the fixed armature type above mentioned excepted.

In the Case of a Two-Cylinder Engine it will be noted from the foregoing table that the armature rotates the same speed as in the case of a four cylinder machine.

Two Sparks are Required in Succession, at intervals of 90 degrees, the firing of a two-cylinder engine being unsymetrical.

Two Segments of the Four-Way High-Tension Distributor at 90 Degrees are Therefore Connected up to the respective cylinders, and the other two are connected to the frame, and the sparks not required dissipated in that manner.

REMAGNETIZING AND RESTORING STRENGTH OF MAGNETOS.

The Magnets Used on Both Low and High-Tension Machines are of special tungsten steel made as hard as it is possible to obtain them, so hard that a sharp file cannot make any impression on the metal.

Much Depends on the Class of Steel Used—a special grade known as magnet steel being now always adopted—whether the machine will retain its sparking efficiency unimpaired for some years.

The Retention of Magnetism by steel is a very curious and interesting property.

It Resides Only on the Surface of the Steel, and it is found that a much stronger magnet is obtained, weight for weight, by making it in sections, one placed over the other, than in using a massive single magnet.

Most Magnetos have three magnets superimposed, some have four.

Soft Steel is Easier to Magnetize Than Hard Steel, but the former loses its quickly if submitted to vibration.

The Hard Steel Magnet Loses Its Magnetism Very Slowly, although the magneto has, as a matter of course, to withstand much vibration from the engine, etc.

Any Standard Type of Magneto should show very little loss of strength for three years, but after this period it is as well though not an actual necessity, to have the magnets brought up to maximum strength again.

In All Cases the makers or agents can do this with very little delay and at small cost.

The Magnetizing Process requires the use of a powerful electromagnet, across the poles of which the steel magnet to be strengthened is placed, so that opposite poles are alwas in contact, that is, the north pole of the steel magnet touches the south of the electro-magnet ,and the south pole of the former touches the north pole of the latter.

The Magnets are Left in Contact for a Certain Time till the steel is "saturated."

This is Known by the magnet being able to support a certain weight of iron from 10 lbs. to 20 lbs., according to size of magnets.

Another Way of Magnetizing, useful in an emergency, is to wind on each limb of the magnets 50 turns of thick COPPER WIRE INSULATED, about No. 14 or 16 gauge, and pass a direct flow of current through this winding.

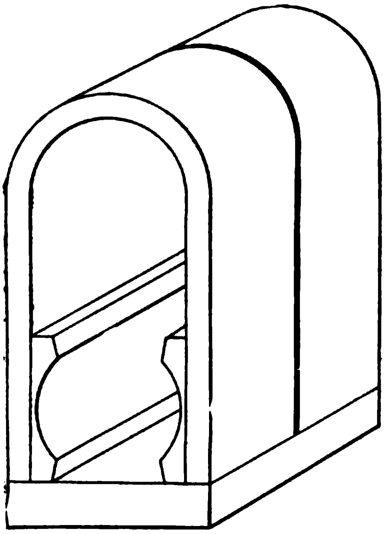


Fig. 1. Permanent Magnets, Pole Shoes and Base.

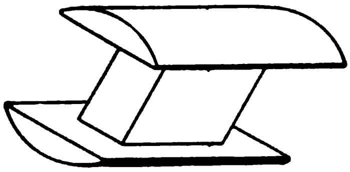


Fig. 2. Armature Core.

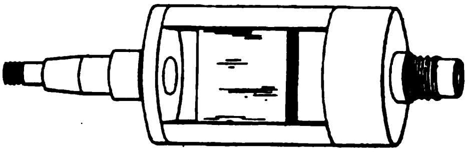


Fig. 3. Armature Core with End Plates and Shafts.

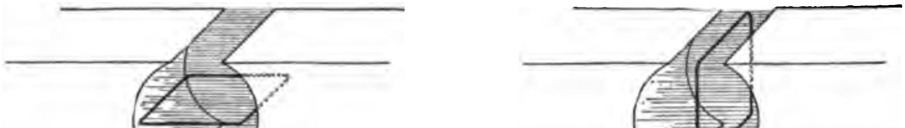


Fig. 4.

Fig. 4A.

Diagrams of Electro-Magnetic Induction.

The Structural Portion of a Magneto.

CHART No. 92.

INSTRUCTION No. 20.

EXPLANATION OF MAGNETO ACTION:—Describing the Generating of Current and the Operation of the Contact Breaker, Condenser, Distributor and Safety Spark Gap.

The High Tension Magneto is not only a current generator or a substitute for the battery, but combines all the elements of a complete ignition system, except the plugs and switch.

It Performs Three Separate Essential Functions as follows:

GENERATING CURRENT.

TRANSFORMING THE CURRENT TO A HIGH PRESSURE.

DISTRIBUTING THE HIGH TENSION CURRENT TO THE INDIVIDUAL CYLINDERS.

Besides These Main Functions, a number of minor functions have to be performed.

We Will First Describe the Means Provided for Generating Current, and the way in which the function is accomplished.

THE CONSTRUCTION.

The Structural Portion of the Magneto consists of permanent magnets of inverted U-shape, though they are generally referred to as horseshoe magnets. In the magneto here illustrated (Fig. 1, Chart 92) there are two such magnets arranged side by side. The free ends of the U are known as the poles, one as the north pole, and the other as the south pole.

To These Poles Are Secured Cast Iron Blocks, known as pole shoes, and the magnets are then fastened to a base of non-magnetic material (brass).

The Pole Shoes Are Bored Out Cylindrically to receive the armature, which is of substantially cylindrical form.

THE ARMATURE.

The Later Consists of an Armature Core of Soft Iron of H-shaped cross section; also referred to as a shuttle armature (Fig. 2). This core of soft iron serves to form a bridge for the magnetic flux between the pole shoes, and also to carry the winding in which the current is induced.

The Armature Core is First Insulated with mica or similar material.

Then It Has Several Layers of Heavy Insulated Wire Wound upon it.

To the End of This Heavy Wire is connected the beginning of a very fine wire insulated with silk, which is wound on the core until the slot is filled almost to the height of the cylindrical portion, after which a wrapping of insulating cloth is applied, and bands are put around the circumference of the armature to prevent the wire and insulating material from flying out and coming in contact with the pole shoes when the armature is rotated at high speed.

Then Circular End Plates Into Which short Shafts are Screwed and riveted are secured to the armature core.

The End Plate and their relation to the core are seen in Fig. 3.

TWO WINDINGS ON THE ARMATURE.

It Will Thus Be Noted That There are Really Two Windings on the Armature (where as the low tension magneto has but one winding) —an inner winding of relatively few turns of heavy wire, and an outer winding of a relatively large number of turns of fine wire. The winding of heavy wire, or primary winding, serves primarily for generating the current, and, in connection with the fine wire or secondary winding, it also serves for multiplying the pressure or voltage to such an extent that it will produce a spark between the terminals of the spark plug in the cylinder.

The Way in Which the Current Is Generated in the Primary Winding may now be explained as follows:

LINES OF FORCE.

In Any Magnet There are What are Known as Magnetic Lines of Force which pass through the magnet from the south pole to the north pole and return outside the magnet from the north pole to the south pole, thus forming closed circuits.

In a Magneto the Magnetic Lines of Force Flow from the pole shoe of the north pole to the pole shoe of the south pole through the armature core, and the two air gaps between the armature core and the pole shoes.

The Space Between the Pole Shoes constitutes a magnetic field of force.

HOW CURRENT IS GENERATED IN THE PRIMARY WINDING.

The Generation of Current in the Primary Winding is based on the following principle:

When a Loop of Wire Is Moved in a Magnetic Field in such a way that the number of magnetic lines of force included by it changes, there is induced in the loop an electro-motive force or electrical pressure which is directly proportional to the change in the number of lines included, and inversely proportional to the time in which the change occurs.

This Principle is Applied in the Magneto, as shown in the sketches Figs. 4 and 4a, Chart 92.

In Fig 4 the Plane of the Loop is Parallel With the Lines of Force, and none are therefore included by it, in Fig. 4a the plans of the loop is perpendicular to the lines of force, and practically all are included by it.

Therefore in moving the loop from the position shown in Fig. 4 to that shown in Fig 4a—in other words, in rotating it through a quarter circle—the number of lines included is changed from zero to the maximum, and this causes an electric pressure to be induced in the loop, which in turn causes a current to flow in it.

The Pressure Would Still Be Induced if the Loop Were Opened at One Point, but the current, of course, can only flow if the loop (or circuit) is closed.

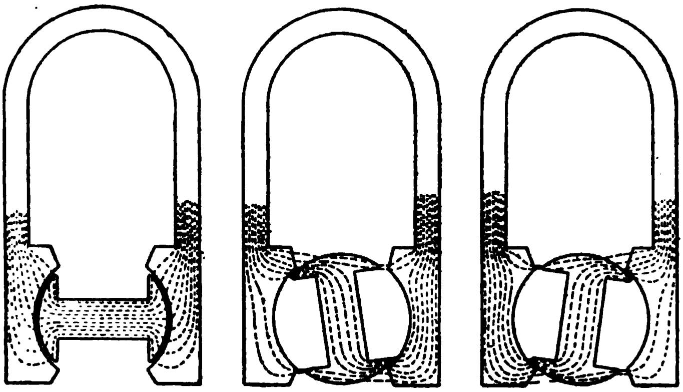


Fig. 1. Fig. 1a. Fig. 1b.

Diagrams Showing Distribution of Magnetic Flux from Various Armature Positions.

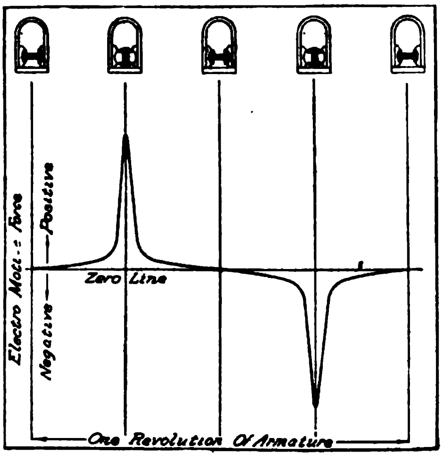


Fig. 2. Curve of Primary Electromotive Force.

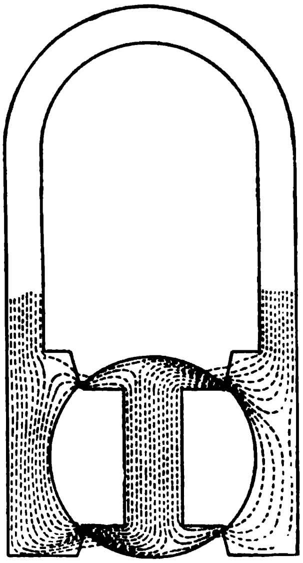


Fig. 3. Diagram Showing Armature Cross Magnetization. Armature is now in a Vertical Position.

CHART No. 93.

The Actual Value of the Electro-Motive Force Induced at any moment is proportional to the rate of change of the number of magnetic lines of force included in the loop.

If a Single Rectangular Loop Were Rotated Uniformly between the pole pieces, as represented in Figs. 4 and 4a, with no magnetic material between the pole pieces, the number of lines included would change most rapidly when the loop was in a horizontal position as in Fig 4, and would gradually decrease and become nil as the loop approached the vertical position indicated in Fig 4a.

In an Actual Magneto, with an armature core of magnetic material, the conditions are somewhat different.

As Long as a Considerable Portion of the Armature Pole Face is Opposite the Face of the Pole Shoes, there is little variation in the number of lines of force passing through the armature, but when the armature core approaches the vertical position where its pole faces are midway between the pole shoes, the number of lines of force through the armature decreases very rapidly, with the result that a high electro-motive force is induced for a short period, representing only a small fraction of a half revolution.

It Should Be Further Pointed Out That the Direction of the Electro-Motive Force Induced in the Loop Is Different according to whether the number of lines increases or decreases, and also depends upon the direction in which the lines pass through the loop.

If Instead of a Single Loop a Number of Turns is Used, the electro-motive forces induced in the individual loops are added together.

It Will Now Be Easily Understood that when the armature core is in the position indicated in Fig. 1, Chart 93, although the maximum number of lines of force then pass through the core, and the primary winding on it, no electro-motive force is induced, as a slight motion of the core to one side or the other results in no change in the number of lines of force, and it is the change; or, rather, the rate of change in the lines of force through the primary winding, that counts.

But as the Armature Core Comes Into the Position Shown in Fig. 1a the number of lines of force through it very rapidly decreases, and it reaches zero as the core attains its vertical position.

A Little Later the Lines of Force Begin to Pass Through the Core in the opposite direction, as is indicated in Fig. 1b.

WHAT HAPPENS DURING THE REVOLUTION OF ARMATURE.

In Fig. 2 is Shown the Curve of Electro-Motive Force induced during one complete revolution of the armature.

In This Diagram horizontal distance represents rotary motion of the armature, while vertical distance is a measure of the electro-motive force induced in the primary winding.

The Figures on Top of the Curve show the correspoding positions of the armature.

Starting at the Left of the Diagram it will be seen that when the armature core extends across from pole shoe to pole shoe there is no electro-motive force induced.

The Electro-Motive Force Increases at First Very Slowly, then more rapidly, and after a quarter turn it attains its maximum value, and then drops off in the same manner until when the armature core is in the horizontal position again it becomes zero again.

A Moment Later an Electro-Motive Force Begins to Be Induced in the Opposite Direction, which, like the first one, increases very slowly at first, and then more rapidly, attaining its maximum value when the armature core reaches its vertical position.

From That Point On It Decreases Again, and after another quarter turn, when the revolution is completed, it is again zero.

It Will Thus Be Seen that during turn each of the armature there are induced in the primary winding of the armature two electrical impulses in opposite directions; these impulses last only for a small fraction of the time of a revolution, and are equally spaced.

The Electro-Motive Force or Tension of These Impulses Is Comparatively Low, and entirely insufficient to cause a spark to jump between spark points separated by even the shortest air gap.

The Next Step, Therefore, consists in trasforming these impulses or multiplying their pressure several thousand times.

THE SECONDARY WINDING.

It Is For This Purpose That the Fine Wire (Second Winding) Is Provided on the Armature. When the armature is being rotated between the pole pieces, an electro-motive force is being induced in the secondary or fine wire winding, the same as in the primary or coarse wire winding, and many times greater, but still not great enough to cause a spark to jump across the spark plug gap.

We Have Already Seen That the Electro-Motive Force Induced in a Winding depends upon the rate of change in the number of lines of force included by the individual turns, and also upon the number of turns.

So In Order to Produce the Highest Possible Electro-Motive Force in the Secondary Winding, it is first made with as many turns as there is room for.

Next, since the rate of change in the lines of force through the individual coil produced by the rotation of the armature is not rapid enough, some other means for changing them is resorted to.

The Method Used is as Follows:

The Primary Winding on the Armature is ordinarily closed upon itself.

This Causes a Current to Flow in it more or less proportional to the electro-motive force.

That Is, the current is at a maximum when the armature core is in a vertical position.

At That Time There are Practically no Lines of Force from the permanent magnet passing through the central part of the core. But the heavy current flowing in the primary winding makes of the core an electro-magnet setting up a magnetic field at right angles to that of the permanent magnets. (See Fig. 3, Chart 93.) This effect is technichally referred to as armature reaction.

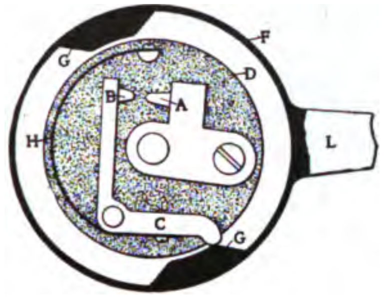


Fig. 1. Circuit Open on interrupter

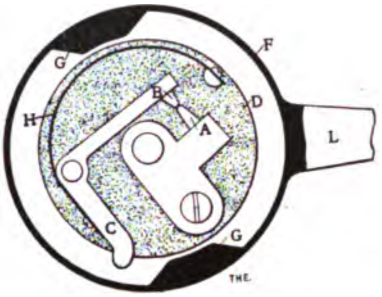


Fig. 1A. Circuit Closed on Interrupter

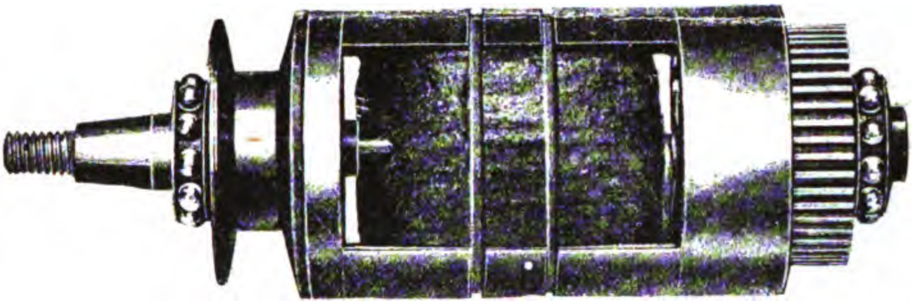


Fig. 2. A Photographic View of a Double Wound High Tension Armature.

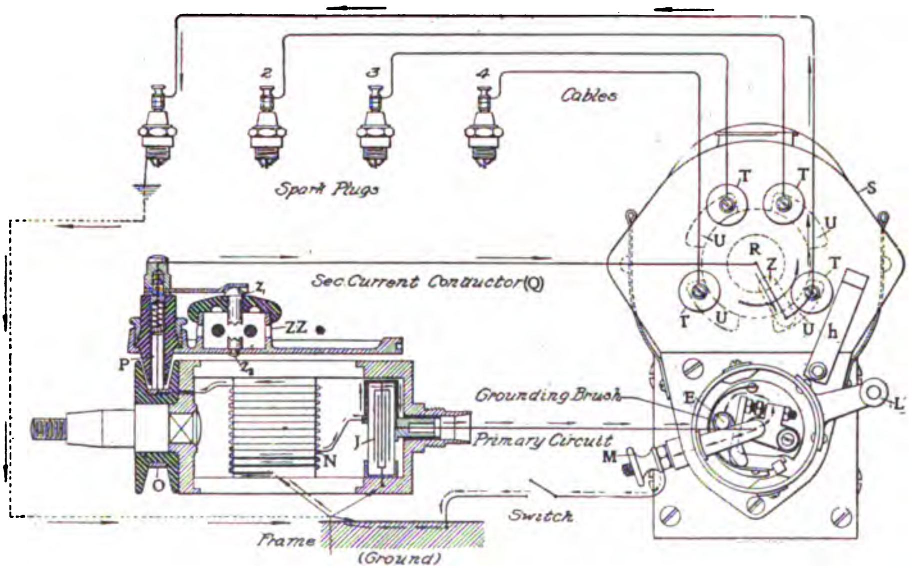


Fig. 3. Diagram of Connections.

CHART No. 94.

Now, If At This Moment the Primary Circuit Be Suddenly Opened the current in it will almost instantly cease flowing, and the magnetism set up by this current will vanish.

These Lines of Force, of course, are also included by the turns of the secondary winding, and as they are withdrawn so exceedingly rapidly, and since there are such a large number of turns in the secondary winding, the result is that an enormous electro-motive force is induced in the secondary winding, which (at normal armature speeds) will cause a spark to jump across a gap in the atmosphere of from one-half to three-quarters of an inch long.

ACTION OF THE CURRENT BREAKER.

To Accomplish This Breaking of the Primary Circuit at the Proper Monment and then closing it again, a device known as a circuit breaker or interrupter is used.

This is Carried on the Armature Shaft opposite the driving end.

It Consists essentially of a stationary insulated contact point A (see Fig. 1, Chart 94) and a moveable contact point B on one arm of the bell crank C. Both of these parts are mounted on a brass disc D, which is securely fastened to the armature shaft and rotates with it.

The Stationary Contact A is Insulated from the supporting disc D, while the movable contact B is in metallic connection with it, and the disc D is grounded to the frame of the magneto by a carbon brush E. (See Fig. 2, Chart 95.))

The Circuit Breaker Is Surrounded by a Cylindrical Housing F, to the interior surface of which at diametrically opposite points are secured steel cam blocks GG.

Ordinarily the Two Contact Points A and B are kept in contact by a spring H. As the disc D rotates the outer arm of the bell crank C comes in contact with the cam block G, whereby the contact points A and B are separated momentarily. (Fig. 1, Chart 94.)

As Soon as the End of the Bell Crank C passes cam block G the spring H brings the two contact points A and B together again. (Fig. 1A, Chart 94.)

The Stationary Contact Block A is connected with one end of the primary winding of the armature, through a screw passing through the center of the armature shaft.

The Other End of the Primary Winding Has Metallic Connection With the Armature Core; in other words, it is grounded.

It Will Now Be Readily Understood How the Current flows through the primary circuit (Fig. 3, Chart 94). Originating in the primary winding p w (Fig. 2, Chart 95) on the armature, it flows through the contact breaker screw I to the stationary contact A, thence across to the movable contact B, from which it is led through the contact brush E, into the metallic framework of the magneto, whence it returns to the beginning of the primary winding, which is also connected or grounded to the frame.

THE CONDENSER.

When the Two Contact Points A and B are Suddenly Separated there is a tendency for the current to continue to flow across the gap, it possessing a property similar to the inertia of matter.

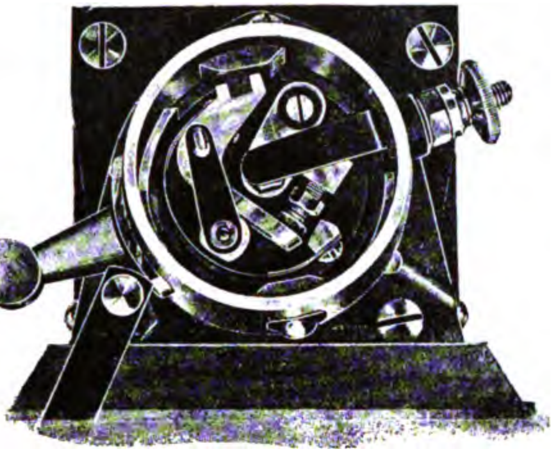


Fig. 1. Photographic View of the Circuit Breaker or Interrupter.
(See detailed description in Fig. 1 and 1A, Chart 94.)

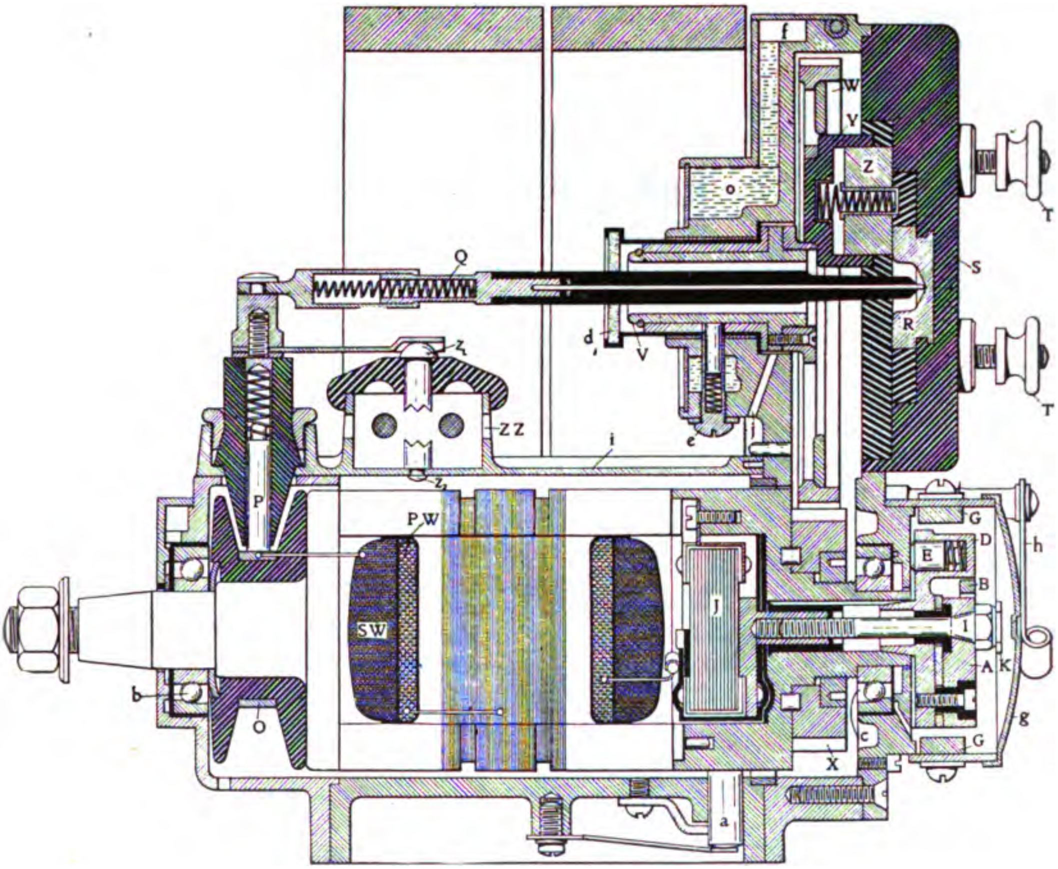


Fig. 2. Longitudinal Section Through Magneto.

CHART No. 95.

This Would Result in a Hot Spark being formed between the contact points, which not only would burn the points away rapidly, but also would prevent a rapid cessation of the current, which, as already explained, is necessary in order to effect a rapid change in the lines of magnetic force through the armature and a high inductive effect in the secondary winding.

To Obviate This Effect a condenser (J-Fig. 3, Chart 94, and Fig. 2, Chart 95) is employed, which in the Bosch magneto is placed in a hollow of the armature end plate at the circuit breaker end.

This Condenser Consists of two sets of tinfoil sheets, sheets of opposite sets alternating with one another, and being separated by sheets of insulating material. All the sheets of each set are metallically connected, and one set is connected to the conductor leading from the primary winding to the stationary contact point A, while the other set is grounded.

In Other Words, the Condenser is Shunted across the interrupter.

Such a Condenser is capable of Absorbing an Electrical Charge, and its capacity is so proportioned that it will take up the entire charge of the extra current produced when the contact points A and B separate; that is, the extra current, instead of appearing in the form of a spark across the gap between A and B, passes into the condenser J. In this way the objectional arcing or burning at the contact points is avoided and the current flow in the primary circuit is more quickly stopped.

HOW DRIVEN AND SET.

The Magneto Armature is Positively Driven from the engine crank shaft, and the current impulse in the armature always occurs when the piston is in a certain position.

Since in Regular Operation of the Motor the charge is ignited just an instant before the end of the compression stroke, the magneto armature is so set relative to the engine crank shaft that the maximum induction effect occurs at this moment.

It is, However, Necessary to Be Able to Vary the Point in the Cycle at which the ignition occurs, since, when the engine is cranked by hand, the spark must occur after the end of the compression stroke, or else the engine may kick back.

VARYING THE TIME OF THE SPARK.

In Order to Make It Possible to Vary the Time of the Spark the circuit breaker housing F is so arranged that it can be rocked around its axis, being provided with a lever arm L for that purpose, from which connection can be made to a spark timing lever on the steering post.

It Will Readily Be Understood that if the armature shaft turns right-handedly, and if then the circuit breaker housing is moved through a certain angle in a right hand direction, the contact points A and B will separate later, with relation to the position of the motor crank shaft; while, on the other hand, if the housing F is moved in a left hand direction the circuit breaker point will open earlier. In this way the point at which the spark occurs can be shifted through an angle of 30 degrees.

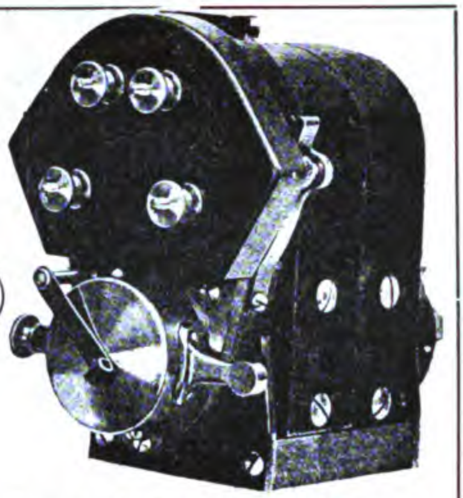


Fig. 1—A Bosch DU-4 Type of High Tension Magneto. Cover is over the Distributor and Breaker Box.

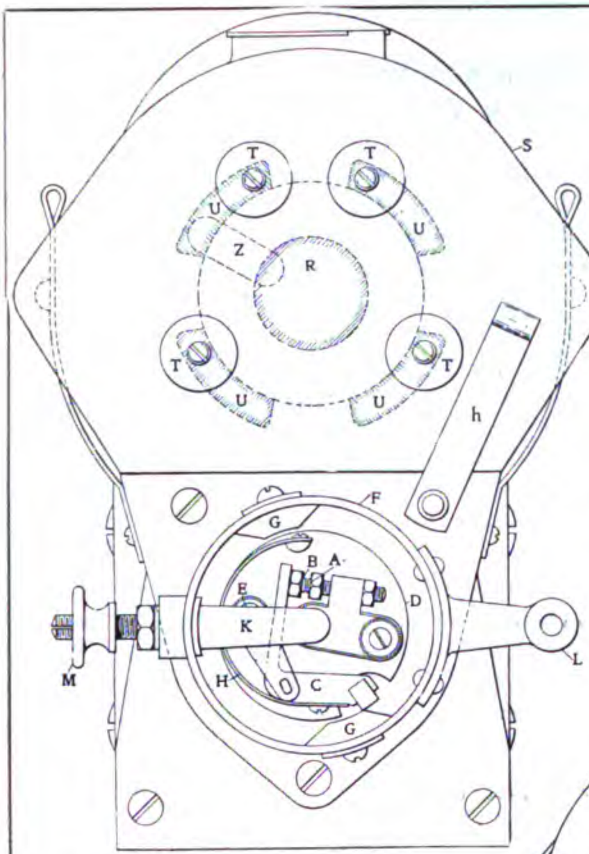


Fig. 2—Front View of the Magneto Showing Details of the Circuit Breaker and Distributor.

Distributor Parts

T—Are terminals to spark plugs.
Z—Brush.
U—Segments connected with terminals on which brush slides.
R—Connects with brush P in fig. 2, chart 95.
For name of other parts see fig. 2, chart 95.

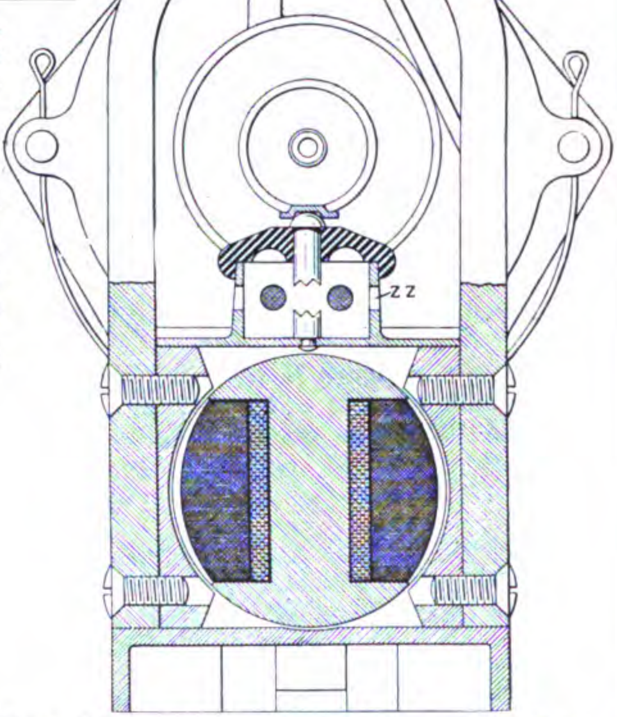


Fig. 3—Cross Sectional View of Magneto. ZZ—Spark gap.

CHART No. 96

TO STOP THE MAGNETO.

It is Also Necessary to Be Able to Stop the Magneto from producing sparks when it is desired to shut down the motor.

To this End a sheet metal strip K is provided which contacts with the stationary contact point A of the circuit breaker and leads to a binding post M on the circuit breaker housing.

From This Binding Post a Wire is Carried to a Switch on the dashboard.

One Side of This Switch is grounded.

When the Switch is Closed the current generated in the primary winding of the armature flows to contact point A, thence through strip K, binding post M and connecting wire to the switch, whence it passes through a wire into the framework of the car and returns to the beginning of the primary winding. The effect of this is that the primary winding is short circuited all the time, and the opening and closing of the contact points A and B have no effect.

In Technical Terms, the circuit breaker is cut out.

The Flow of the Primary Current can easily be followed in the diagram of connections, Fig. 3, Chart 94, where its direction when the magneto is working regularly is indicated by full arrows, and its return path when the magneto is running but not producing sparks is indicated by dotted arrows.

THE DISTRIBUTOR.

It has already been explained how the high tension current is induced in the secondary or fine wire winding of the armature at the moment the current ceases in the primary winding.

It Remains to Explain how this high tension current is distributed to the four spark plugs of a four cylinder engine in succession.

The Beginning of the secondary winding S W (Fig. 2, Chart 95) is connected to the end of the primary winding at N, Fig. 3, Chart 94, and since one end of the primary winding is grounded, the secondary is also grounded through the primary. The end of the secondary winding leads to an insulated contact ring O, Fig. 2, Chart 95, at the driving end of the magneto.

From This Ring the current is taken off by a carbon contact brush P.

From the Brush Holder the Current Is Carried through a spring contact conductor Q to the central distributor contact R.

The Distributor Consists of a disc of insulating material S, in which are imbedded on the inner side one central cylindrical contact piece R and four annular sector shaped contact pieces U U U U (Fig. 2, Chart 96).

The Distributor Also Comprises a Shaft V, which carries a gear wheel W meshing with a pinion X on the armature shaft.

The Gear Wheel W has twice the number of teeth as the pinion, and the distributor shaft V therefore makes one turn while the armature makes two.

The Gear Wheel W Carries a Brush Holder Y containing a carbon brush Z, which is adapted to make contact simultaneously with the central distributor contact R, and with one of the annular distributor contacts U.

The Distributor Sectors are surrounded at the inside and outside by annular rings of a highly insulating material, since they carry the high tension current.

The Reason For Driving the Distributor at One-Half the Armature Speed is as follows:

The Armature, as already stated, turns at the speed of the engine crank shaft.

The Magneto Here Described is for a four cylinder, four cycle engine.

In Such an Engine each cylinder requires a spark once in two revolutions of the crank shaft.

The Distributor is Therefore Geared So That It Makes One Revolution to Two Revolutions of the Crank Shaft and establishes connection between the high tension or secondary winding of the armature and the spark plug of each cylinder once in every two revolutions of the crank shaft.

Each of the Four Annular Contact Segments U has secured to it a binding post T on the face of the distributor disc, and each of these binding posts is connected by a high tension (highly insulated) cable to one of the spark plugs.

There Remains to Explain Only the Function of the safety spark gap ZZ. A magneto must be so designed that it will give a sufficiently hot spark at a comparatively low engine speed, and the ability to do this implies the ability of generating very large and hot sparks and enormously high tensions at high engine sped.

The Actual Electro-Motive Force or Tension Produced in the secondary winding is, however, limited by the size of the spark gap in the spark plug, for as soon as the tension reaches a point sufficient to jump this gap the discharge occurs, and there is no further increase in the electro-motive force.

Suppose, However, That the Terminals of the Spark Plug are by Chance Bent Unduly Far Apart, or that one of the high tension connections to the spark plug accidentally comes loose, then there would be no chance for the spark to pass in the ordinary way, and the electro-motive force in the secondary winding might build up to such an extent as to puncture the insulation of the winding, which would ruin the armature.

To Avoid This the safety spark gap is provided.

It Consists Of a little chamber formed on top of the armature cover plate, with a top of insulating material.

Into the Top and Bottom of this chamber spark terminals z1 z2 are set.

The Spark Terminal in the Bottom is, Of Course, Grounded; and that in the insulated top is connected with a high tension contact brush P by a strip connecter.

The Gap Between the Two Terminals z1 z2 is longer than the gap between the spark plugs, and ordinarily no spark will pass between these terminals; but if, owing to the conditions already mentioned, no spark can pass at the regular spark plug and the electro-motive force in the secondary winding attains an abnormal value, a discharge will occur at the safety spark gap, thereby preventing the secondary electro-motive force from rising still higher.

Some of the Mechanical Details of the Magneto May Be Seen From Fig. 2, Chart 95 and Fig. 2 and 3, Chart 96, which are three actual views of the Bosch Model DU-4.

The Same Lettering is used in these views as in the sketches. It will be observed that a spring pressed contact brush a (Fig. 2, Chart 95) is placed in the base of the magneto bearing against the circumference of one armature end plate.

The Object of This Contact Brush is to make absolutely sure that the revolving metallic parts of the magneto are at all times in good metallic connection with the stationary part and the frame of the car, no reliance being placed upon the ground connection through the bearing.

The Armature Shaft is Mounted in Annular Ball Bearings b and c, which are provided with oil guards so that any lubricant supplied to them will not be easily lost or reach the insulating parts.

The Armature Tunnel is Closed on Top by an aluminum cover i, and the front of the circuit breaker housing is provided with a brass cover g, which is held in place by means of a hinged flat spring h, so it can be very quickly removed and replaced.

The Distributor Shaft is Mounted in a Plain Bronze Bushed Bearing, which is lubricated by means of a wick oiler e.

A Felt Washer d encloses the inner end of the bearing, while at the distributor end is provided a channel j for the escape of any oil working out of the bearing, so it will not reach the distributor.

A Large Size Oil Well is Provided for the wick oiler e, and is closed by a hinged cover f on top.

A Number of Photographs are Also Shown of the Bosch DU-4 Magneto, which may aid those not familiar with mechanical drawings to grasp the arrangement of parts.

So Far as the Above Description of the Individual parts and Their Functions is Concerned, That applies to Any True High Tension Magneto; that is, a magneto having both a low tension and a high tension winding on the armature.

Each of the Elements Here Described is Always Present and serves the purpose indicated, though the relative location of the parts varies somewhat.

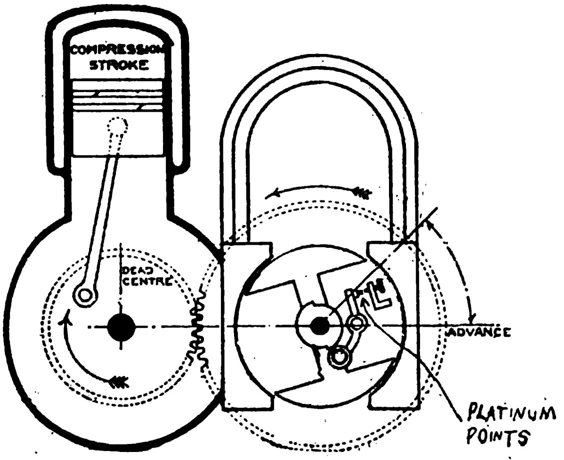


Fig. 1—Diagram showing relative positions of Engine, Piston, Magneto, Armature and Interrupter when timed for Advanced Ignition

The positions as shown are approximate only, and should not be taken as an exact guide for setting the ignition timing for all types of machines. In some cases the armature would not required to have moved so far around to the left to obtain the best results for full advance.

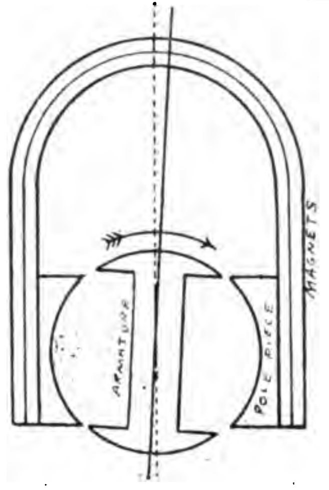
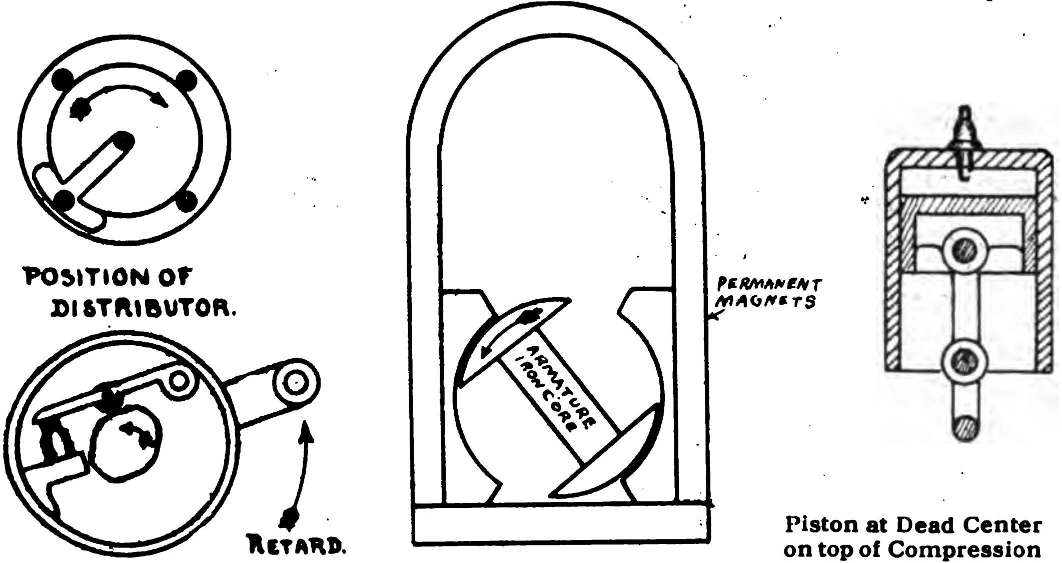


Fig. 2—In timing an engine fitted with Magneto Ignition the most important factor is to have the armature held in a maximum position as shown in the diagram, wherein the armature has just moved a few degrees past the true vertical position. The contact breaker platinums should just separate when the armature is in a maximum position. In cases where the timing is fixed this position should agree with the piston when about ⅛-inch before the top dead center is reached. On many magnetos the armature can be held in the firing position for setting by means of a catch or pin.



Position of Breaker. Position of Armature. Piston at Dead Center on top of Compression Stroke

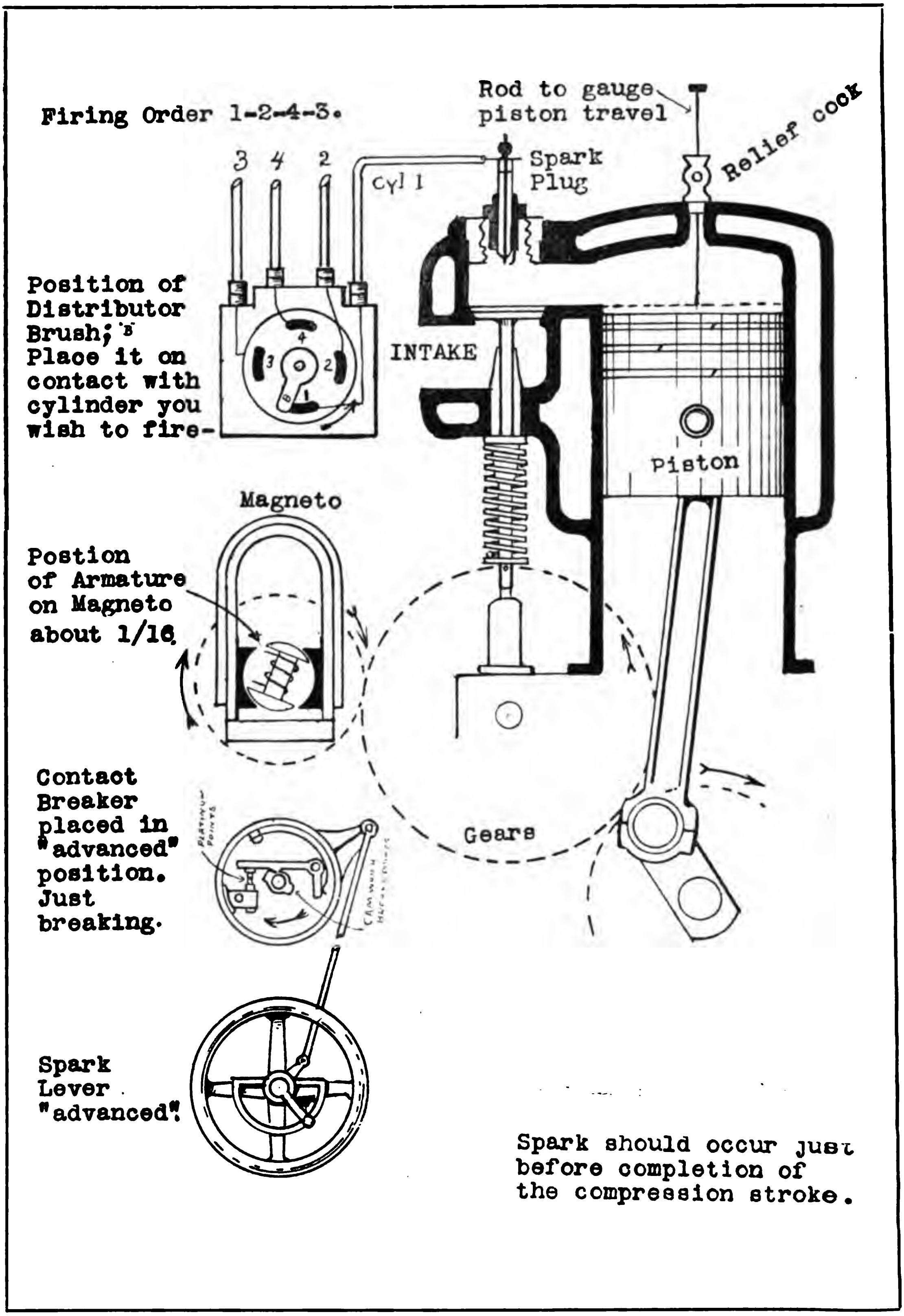
Fig. 3—Method for Timing the Splitdorf Magneto.

First—Place piston on Dead Center on head of compression stroke.

Second—Place Armature in position shown and retard contact breaker. The contact breaker will adjust itself as it is set at the factory to time with the armature—if out of time for any reason then the position of breaker should just be breaking.

Third—The Distributor Brush must be set on the contact to cylinder which is to be fired.

CHART No. 97



Firing Order 1-2-4-3.

Position of Distributor Brush; "B" Place it on contact with cylinder you wish to fire-

Postion of Armature on Magneto about 1/16

Contact Breaker placed in "advanced" position. Just breaking.

Spark Lever "advanced".

Spark should occur just before completion of the compression stroke.

Method of Timing and Setting a High Tension Magneto.

CHART No. 98.

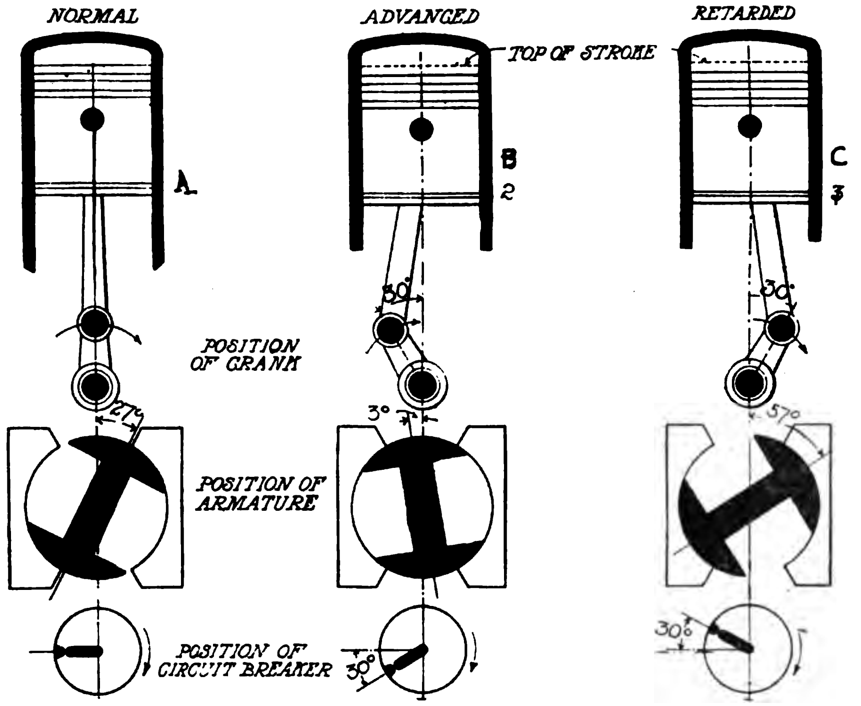


Fig. 1—Positions of Piston, Magneto Armature and Contact Breaker to set the Eismann Magneto.

To set the Eiseman magneto, retard the ignition by pushing the lever as far as possible in the direction of rotation. Turn the motor by hand until the piston in the cylinder corresponding to the distributor contact in firing position is just beyond the dead center. Then turn the armature around until the mark on the cam is opposite the pin in the bearing plate and fix the driving pinion in this position. If the magneto is of the pivoting type, ignition is retarded by rocking the magneto as far as possible in the direction of rotation and the rest of the operation is the same as before.

In Fig. 2 is shown the magneto of a four-cylinder motor with the distributor in position for firing the charge in cylinder No. 1. It will be seen that the piston in that cylinder is at or just beyond the end of its stroke, and that the marks on the timing gears are together. So, then, we can set any magneto by reproducing the conditions in this sketch. Of course the method varies slightly with different magnetos, but the object of all is to get the parts in the relations shown.

In Fig. 1 are shown the relative positions of the piston, crank, magneto armature and contact breaker under the conditions of normal, advanced and retarded ignition. It is assumed for this illustration that the spark is advanced and retarded by moving the contact-breaker disc through an arc of 30 degrees each way from the normal position. The position of the armature of the magneto is not the same in all magnetos, but the relative positions are representative of usual practice.

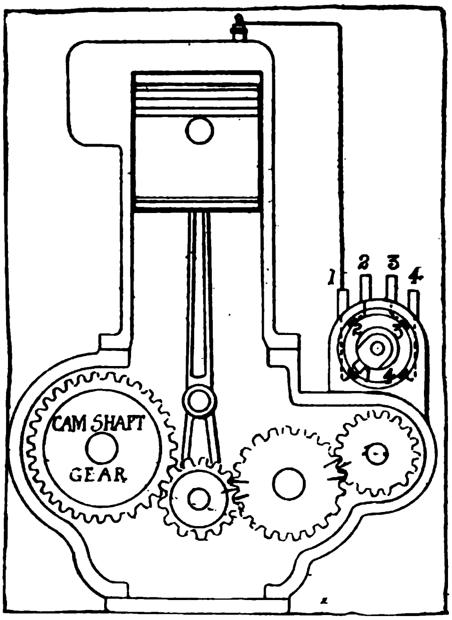


Fig. 2—Magneto Timing Gears

CHART No. 99

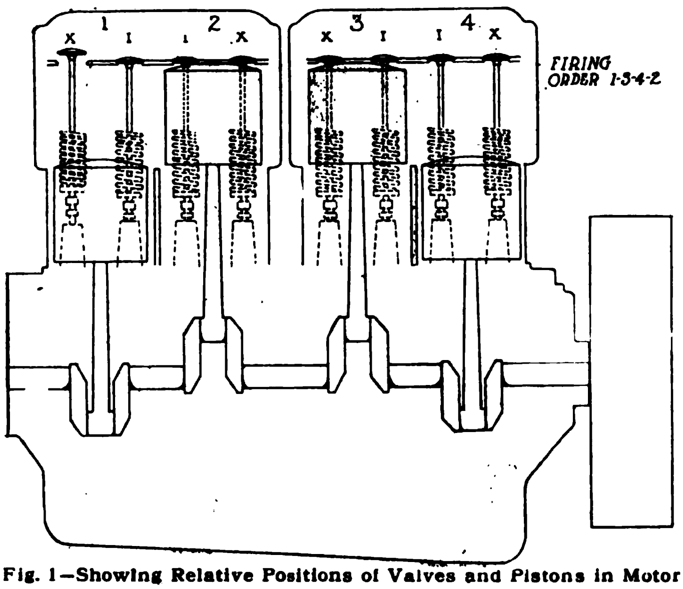


Fig. 1—Showing Relative Positions of Valves and Pistons in Motor

Position of Piston and Valves on an Engine Firing 1-3-2-4

In order that the relation between the valves and pistons may be understood, a diagram is shown in Fig. 1 that may be of some assistance. It shows the relative positions of all the valves and pistons of an ordinary four-cylinder four-cycle motor with one of its pistons on its firing center. A motor is known to be on its firing center when one of the pistons is at the top of the cylinder ready to descend on its explosion stroke. Each cylinder is numbered at the top; the front cylinder being No. 1, the second from the front being No. 2, etc.; the exhaust valves are marked X and the inlets I; and the firing order of the motor is 1-3-4-2. Now, as there is a positive relation between the valves and pistons, there is a rule by means of which the firing center of a motor can readily be found by inspecting the exhaust valves. It is as follows: "When an exhaust valve is open the following cylinder to fire is on its firing center." To apply this rule one has but to turn the crankshaft with the starting crank until the crank extends vertically upward, and stop. This brings the throws of the crankshaft into the vertical positions shown; then examine the exhaust valves and see which one is open. Having found the open exhaust valve, and knowing the firing order of the cylinders, the rest is easy. For instance if as shown in Fig 2., the firing order is 1-3-4-2, and the exhaust valve of No. 1 cylinder is open, then No. 3 cylinder is ready to fire, or is on its firing center. If it had been found that No. 2 exhaust valve was open, No. 2 piston would be at the bottom of its stroke ready to go up and force the burnt gases out of the cylinder, and No. 4 cylinder would be about to fire. The firing order of any multi-cylinder motor may be learned by cranking the motor and watching the consecutive action of the valves.

Checking the Ignition Timing

It often happens that ignition cables are disconnected from the spark plugs and magneto distributor without the operator taking the precaution of properly labeling or arranging the disconnected wires so that they can be properly replaced.

One rarely has occasion to disengage the gears which drive the magneto or timer; but in cases where this is necessary one should be most careful to see that the gears are properly marked as indicated in Fig. 2. In replacing the wires between the magneto and spark plugs, the first thing to do is to learn the firing order of the cylinders, the next thing to do is to get No. 1 cylinder on its firing center, then on removing the cover of the magneto distributor it should be found that the revolving segment of the distributor is in contact with the stationary segment to which No. 1 cable is connected, as indicated in Fig. 1. The motor then should be cranked slowly, and the direction of rotation of the revolving segment watched. In Fig. 1 the revolving segment turns in a clockwise direction so that it next will make contact with the stationary segment No. 2. As the motor fires 1-3-4-2, the cable No. 2 should lead to No. 3 cylinder, No. 3 to No. 4 cylinder and cable No. 4 to No. 2 cylincer. (Motor Age).

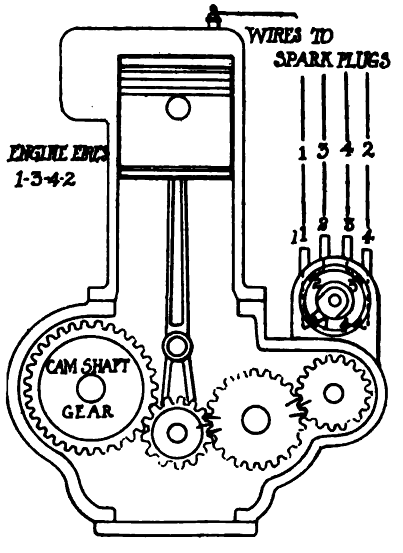


Fig. 2—Checking the Ignition Timing

CHART No. 99A

INSTRUCTION No. 21.

TIMING AND SETTING MAGNETOS:—Hints on obtaining Best Results with Magneto Ignition. Magneto Troubles and Remedies.

TIMING HIGH TENSION MAGNETOS.

When a Magneto Is Assembled the cam and contact breaker are set in the correct relative position.

The "Break" of the Armature Winding is made to occur when the "cheeks" or segmental-shaped sides of the iron armature almost bridge the gap at the top and bottom of the magnet pole pieces.

The Position Is Not Quite Symmertrical, but the "maximum" or most favorable position is slightly in advance in direction of rotation of a vertical line right through the center of the magnets and armature when the latter is set quite symmetrical. One maximum position is shown in the illustration, Fig. 1, Chart 97.

It Will Be Found in Most Types of Magnetos that the contact rocker has full retardation point, that is, the actual break between the platinums agreeing with the armature in this position of maximum effect.

The Reason Is This:—Owing to the necessarily slow rate at which the magneto can be driven for starting, and as the spark has to be slightly retarted to prevent a backfire occuring, the most use must be made of the maximum position, otherwise there would be too weak a spark produced to ignite the gas.

On the Other Hand, it must follow that, on advancing the contact make and break for normal running, the "break" will be occuring at proportionately less favorable positions of magnetic effect; but another factor comes into play, which largely compensates for this, viz., the increasing speed of the armature.

In Practice This Works Well, and prevents the generation of excessively strong sparks, which are not required, and only serve to fuse up the electrodes of the plug.

The Spark Is Made Sufficiently Powerful for Starting on by the use of strong field magnets and breaking circuit in the most favorable position of the armature's rotation.

After Starting, the intensity of the spark will increase as the speed increases, but it will never reach an excessive value, by reason of the advance of the contact maker timing the break before the maximum position.

The "Breaking" Distance Between the Platinums should never exceed 1-50 inch. The amount of range provided for advancing and retarding is greater on some magnetos than others; an average range is 30 degrees.

No Hard-and-Fast Rule Can Be Given as to the best piston positions corresponding to full advance and retardation; but in general, a trial setting might be tried in which the gear wheels are meshed so that, with the contact breaker fully retarded, the piston has moved one-tenth of the firing stroke.

If it Is Found That the Contact Breaker Cannot Be Fully Advanced Without the Engine Tending to Knock, another setting must be made, and the piston moved farther on the firing stroke.

After a Few Trials and careful noting of the pull of the engine, the best setting for the particular conditions will be attained.

Occasionally the Timing Is set to One Fixed Position, a small amount in advance or behind the top dead center, as determined by experiment to give the best results. This method simplifies the control.

A Common Method Quite Often Used In Timing the High-tension Magneto is shown in Chart 98.

POINTERS FOR THE CARE OF MAGNETOS.

There Are Many Individual Types of High-Tension Machines and detailed directions for maintaining them in efficient condition can invariably be obtained from the makers or their chief agents.

As There Is Nothing in a Magneto that has to be periodically recharged, it similarly follows that there is nothing to run down or become exhausted.

The Magnets of the Machine Will—unless roughly handled—keep their strength for three to six years.

Stated Briefly, what must be looked after in any high-tension magneto are:

(1) **The Interrupter, the Platinum Contact Surfaces** of which must be kept well trimmed, carefully adjusted, and cleaned free from any oil, grease or dust.

(2) **The Carbon Brushes,** two or more of which are used to collect the current from the armature and transfer it to the distributor.

These Brushes Are liable to Become Clogged up with grease, or the springs may not act satisfactorily.

(3) **The Bearings of the Amature** and distributor mechanism require efficiently lubricating, and very particular care should be paid to the details given on this matter by the makers.

This Applies Mainly to a Few Machines which are not fitted with ball-bearings, but have plain phosphor-bronze brushes to the distributor or armature.

(4) **The Connecting Wires** from the distributor to the plugs and also those joined to the switch, where such is fitted must be examined occasionally, to see they are securely attached to the respective terminals, and that none of the insulation or rubber covering has become damaged or scraped off.

Sometimes a Loose Wire will chafe against some adjacent metal work, and, with the insulation cut through, a short circuit (which may be either of an intermittent or permanent charter) ensues.

(5) **The Condition of the Sparking-Plugs Is Very Important. Faults May Develop** between the insulation and the metal shell.

Only the Best Plugs Can Be Relied Upon for magneto ignition.

The Adjustment and Setting of the Points is an important matter on a magneto spark plug.

This Should Not Exceed 1-50th of an Inch, or half a millimetre.

The Reason for This is the comparatively low voltage of the spark at the necessarily slow speed of rotation of the armature when starting up.

It Also Ensures that there will be no risk of the spark failing to jump the points under the resistance offered by the highly-compressed charge.

A Large Gap between the plug points.

Would Tend to Strain the Insulation of the Armature, that is, the resistance at the sparking-plug gap under high compression would be so great that a spark might pierce the armature insulation and so pass to "frame."

But Taking Magneto Machines in General, the care taken with the insulating of the winding is such that only very unfair treatment will cause a breakdown.

A Safety Spark Gap Device is now provided on all high-tension machines.

Certain Types of Machines have only one winding on the armature, in which only a low-tension current is induced, the high-tension current being obtained from an independent coil.

This Means that even greater reliability is possible, and there is no more risk than with the ordinary system of coil and accumulator.

The Question of Starting Up Direct on a Magneto is often raised.

The Majority of Users of the system never experience any difficulty in starting the first or second turn, providing the carburation is right and the plugs clean and points correctly set.

The Rotation of the Engine Shaft must be as rapid a movement as possible, and the spark advance lever put as far forward as it can possibly be set without risking backfire.

Only by This Method Is it Possible to Get a Sufficiently Strong Initial Spark.

Occasional Instances may occur in which starting up is impossible on a magneto, and recourse has to be had to an auxiliary battery circuit.

This Can Only Be Attributed to the machine **Not Having Sufficient Capacity at a Slow Rate of Revolutions** to spark under the full compression.

This Difficulty of Starting might only develop after a season or two's use, in which case—and providing the contacts have been seen to—it can only be due to the magnates having weakened a little, but quite enough to cause failure to start, though in actual running it may be quite satisfactory.

As There Is Rarely Any Difficulty in getting the magnets brought up to full strength for a small cost by sending the machine back to the makers or the head agents, it is often as well to have it done.

It Is Recommended that the machine be sent away complete rather than for the owner to take the magnets off and send those alone because, in replacing them, they may be weakened through rough handling, or the poles might be accidently reversed.

A Further Advantage Lies in the Fact that the makers are able thereby to test the machine and return it properly adjusted.

HIGH TENSION MAGNETO IGNITION TROUBLES.

In the Case of the Magneto Ignition Becoming Defective the fault may be in the sparking plugs, in the wiring, or in the magneto itself. If only one cylinder is missing fire, the fault is probably in the sparking plug or cable. The particular cylinder which is "missing" may be located by the method explained under "Troubles and Remedies."

Possible troubles with sparking plugs are:—

(1.) **The Sparking Gap** of the plug may be short-circuited by oil or soot. If this occurs, the plug may be cleaned with a little gasoline and a cloth, or if the plug is very dirty, it may be taken to pieces by unloosening the small lock nut which is situated above the main nut, and the parts can then be thoroughly cleaned before being replaced.

(2.) **The Spark Gap May Be Short-Circuited** by the points fusing together in a bead, owing to the intense heat of the spark. In this case the obvious remedy is to remove the bead by means of a penknife or screw-driver and afterwards to reset the plug points.

(3.) **The Spark Gap May Be Too Big for the Spark to Jump Across** it regularly. The correct distance between the points is only .04 of a millimetre, or one-sixty-fourth of an inch. This is much less than is permissible with the accumulator ignition plugs. When the points are set correctly for magneto ignition, it should just be possible to insert a visiting card between them.

Although All Magneto Machines Are Usually Claimed to Be Dustproof, it is as well not to rely cn this if the machine has to be fitted in such a position that it catches a good deal of oil spray and dust.

A Tight Fitting Leather Cover Strapped on is a very advisable accessory.

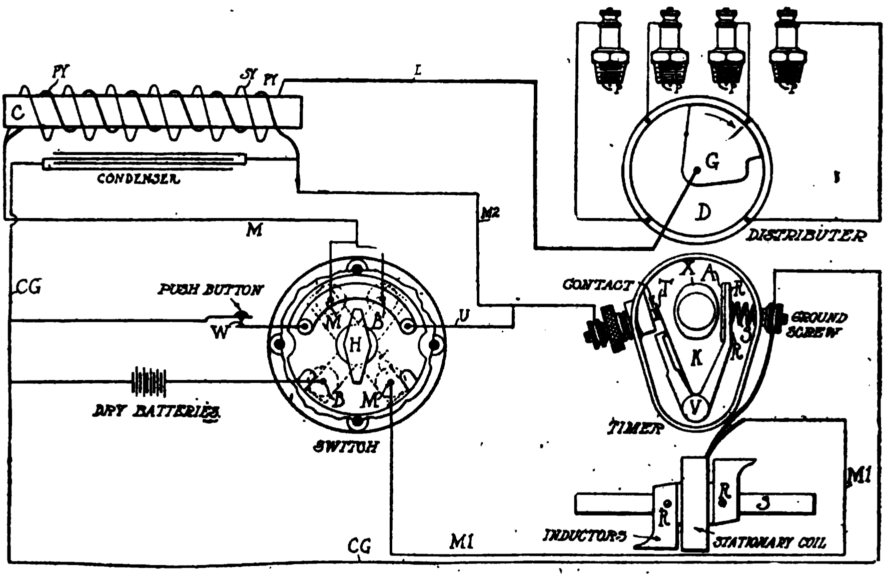
Oil, Especially, Is a source of a good deal of trouble with these machines, as it finds its way onto the connections.

MAGNETO DON'TS.

Never Use a Hammer on a. Magneto. To use the magnets as an anvil is to destroy the residual magnetism.

Before Drawing the Armature out from between the magnets, a thick iron plate should be laid across the pole pieces, to act as a "keeper" during the absence of the armature.

Do Not Wastefully File Away at the platinum points of a magneto contact breaker every time miss-firing is experienced. Such procedure is more likely to make trouble than cure it.



WIRING DIAGRAM OF REMY IGNITION SYSTEM.

Low Tension Magneto, Separate High Tension Coil.

R—The Inductor Armature, the part which rotates with shaft S; the winding or "stationary coil" does not revolve. X—Cam operating the "contact breaker." T—Platinum points on contact breaker. M1 and M2—Low tension or primary wires. L—High tension wire. Switch—By throwing switch on "B" the battery is connected; by throwing switch on M the Magneto.

This Magneto has a Stationary Winding which simplifies the construction, eliminating revolving wires, carbon brushes and all moving contacts. A single winding of coarse magnet wire is imbedded in the pole pieces of the magneto. The rotative part or inductor is a solid steel shaft upon which are mounted two simple forgings or inductor wings, one on either side of the winding. At each half turn of the inductor, the direction of the flow of the lines of magnetic force through the winding is alternately reversed, inducing in the winding two electrical current waves or impulses for each complete revolution.

The stationary winding is directly connected through the magneto circuit breaker with the primary of the non-vibrating step-up transformer coil used with the magneto. The circuit is mechanically broken during the current wave which is of considerable duration (over 60 degrees of the inductor's revolution) The nature of the wave is an almost abrupt rise and fall with a flat top, making possible the large timing range for advance and retard of spark at practically the same heat of spark. The timing of the spark is accomplished by shifting the circuit breaker around the inductor shaft, to which is attached the circuit breaker cam.

The Distributor of the Magneto and its two to one driving gear for the four cylinder motor is for the purpose of distributing the current after it has been sent to the coil and transformed to the high voltage which it is necessary to use at the spark plugs. It will be noted that the one high tension cable leads from the coil to the distributor. For each revolution of the magneto inductor, this cable carries two high voltage current impulses to the distributor, and as the fan-shaped distributor segment is making one revolution to two of the magneto inductor, it can in turn deliver a spark to each of the four cables leading from the distributor to the spark plugs each time the magneto inductor makes two complete revolutions.

The Magneto Inductor must, therefore, with the four-cylinder, four-cycle engine, always be driven at twice the speed of the engine cam shaft or the same speed as the crank shaft. With the six-cylinder, four-cycle engine the magneto distributor is back geared with a ratio of one to three and the magneto must be driven at three times the speed of the cam shaft or one and one-half times the speed of the crank shaft.

With the two-cylinder, four-cycle opposed engine, the magneto does not have a distributor and a single cam is furnished on the magneto, causing but one electrical impulse for each revolution of the magneto inductor. The magneto must then be driven at the same speed as the crank shaft of the engine

The special Step-up Transformer Coil furnished with the Magneto is fitted with a two point switch used to switch from battery to the magneto or vice versa, or disconnect from either to stop the motor. The switch is also provided with a push button for the purpose of starting the four-cylinder or six-cylinder motor from the spark by pushing the button when the switch lever is turned to the battery side. This system makes starting without cranking most reliable, for the reason that the coil is particularly suited to the magneto which is not injured by large current consumption, as would be the case were batteries regularly used. When the battery is in use with the coil, it furnishes then an exceptionally hot spark When the battery is used, it will be understood that the battery current is simply turned through the coil, and distributor of magneto instead of the magneto current. It is intended that batteries be used for starting and relay although the magneto is regularly used for starting.

CHART No. 100

Fig. 1

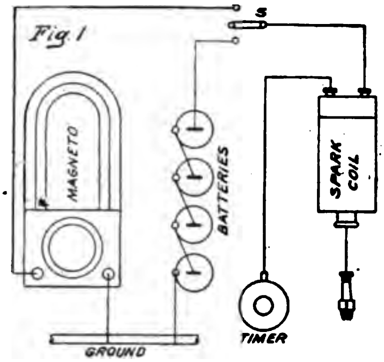


Fig. 2

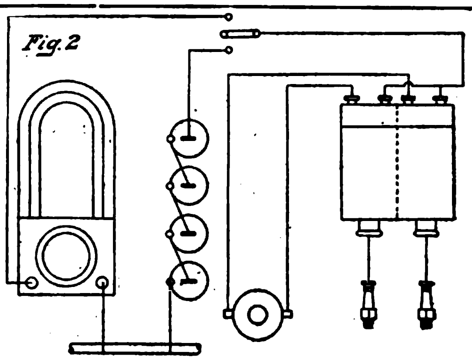


Fig. 3

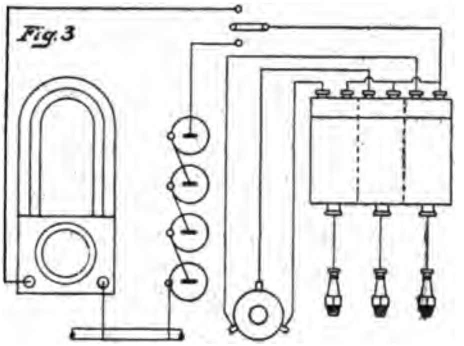


Fig. 4

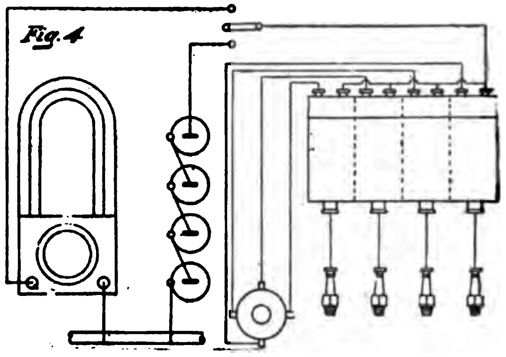


Fig. 5

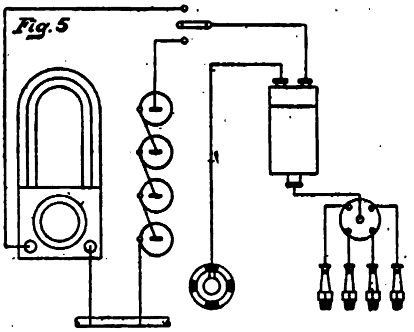
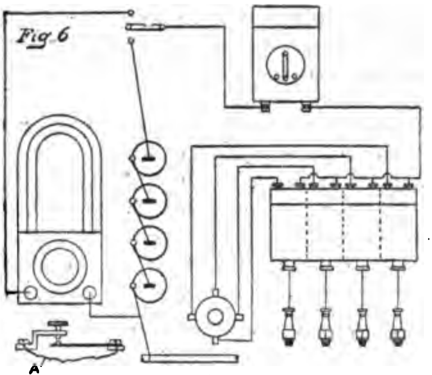


Fig. 6



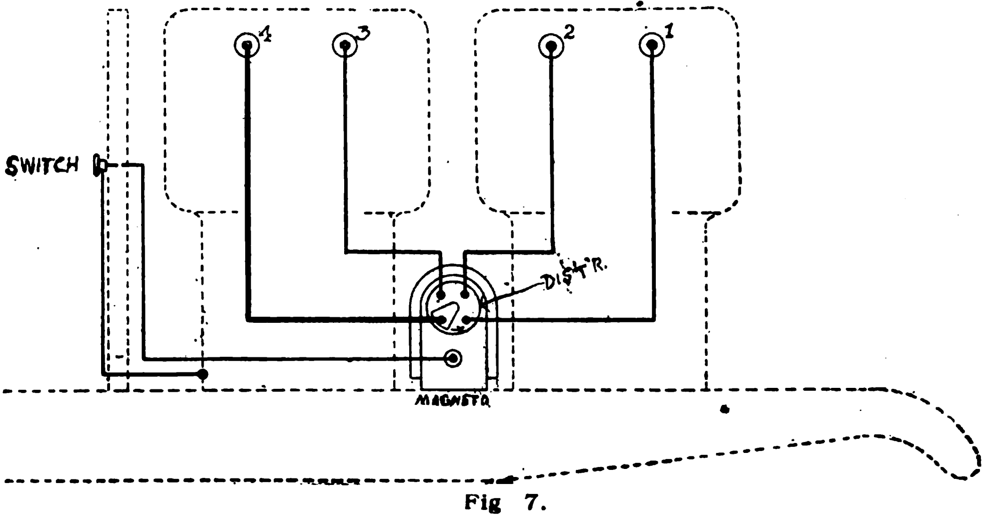


Fig 7.

CHART No. 101.

INSTRUCTION No. 22.

WIRING DIAGRAMS: — Explanation of Various Ignition Systems.

Figure 1, Chart 101 Shows a Diagram for the Wiring of a Single Cylinder Motor for Jump Spark. B is the battery, M the magneto or dynamo, S the switch, C the coil, T the timer and P the plug in the cylinder. G is the ground wire well connected to any part of the engine or frame, preferably, however, on the engine at a point where the current will have as few lubricated joints to pass as possible. The high tension or secondary wire the other end of which is not shown is grounded through the primary by a connection on the inside of the coil box. The switch may have one, two or three throws; that is, the movable part may be so arranged that it will connect with any one of three buttons or so when placed between two buttons it will touch each connecting up two sources of supply at the same time. In another position the movable arm does not touch any of the buttons, which of course is an off position, no current flowing.

When switch S is closed, the current flows from the battery through primary windings to the coil; from the timer when the contact is made through the engine and back through the ground wire to the battery, completing the primary circuit. As soon as the primary circuit is closed by the timer, the vibrator begins to operate on the coil and induced currents of high voltage are produced in the secondary winding. The secondary current passes from the coil to the plug center, jumps to the edge of the plug which is the same as the engine, causing a spark and passes back through the engine by means of the ground wire to the coil thus completing the secondary circuit. It is practically a matter of indifference which way the current flows except that at the time of breaking the circuit the spark jumps from the positive to the negative, pitting the positive surface due to the carrying away of small particles of the metal. For this reason the current is usually directed in such a way that the part of the timer most easily renewed will be the part pitted, this being in general the movable contact. Some recommend the reversal of the direction of the current every few days so that pitting will not be all on one side. This can be arranged with a special polarity change switch.

Shows the Wiring of a Two-Cylinder Engine the arrangements being exactly the same, except the wire which runs to the coil is branched, going into each of the coils, or, as is often done, the wire simply runs to a main terminal of the coil and by an internal connection is carried over to the second coil. The timer in this case of course has two contacts. From the ends of the secondary windings, wires are carried to each of the plugs, the other ends of these windings being internally connected and grounded as previously mentioned. Diagrams for three and also for a four-cylinder engine are shown. The general principle being exactly the same regardless of the number of cylinders. Simply additional coils with their secondary windings connected to the plugs are used.

Figure 3, Chart 101 shows magneto or battery and three cylinder coils.

Figure 4, Chart 101 shows a magneto or battery and four cylinder coils.

Figure 5, Chart 101, a Distributor System Is Shown. Diagram of Wiring for a Four-Cylinder Engine Using but a Single Coil. This is accomplished by means of a device known as a distributor which, as its name implies, is used to distribute to the four spark plugs the secondary current from the single coil and for this reason it is placed between the coil and the plugs. The secondary wire, which would ordinarily in a single engine be connected from the coil to the plug, is in this case connected to the distributor main terminal, while from the four terminals wires are run to the separate plugs. The distributor simply consists of an insulated stationary ring in which are imbedded 4, 6 or 8, according to the number of cylinders in the engine.

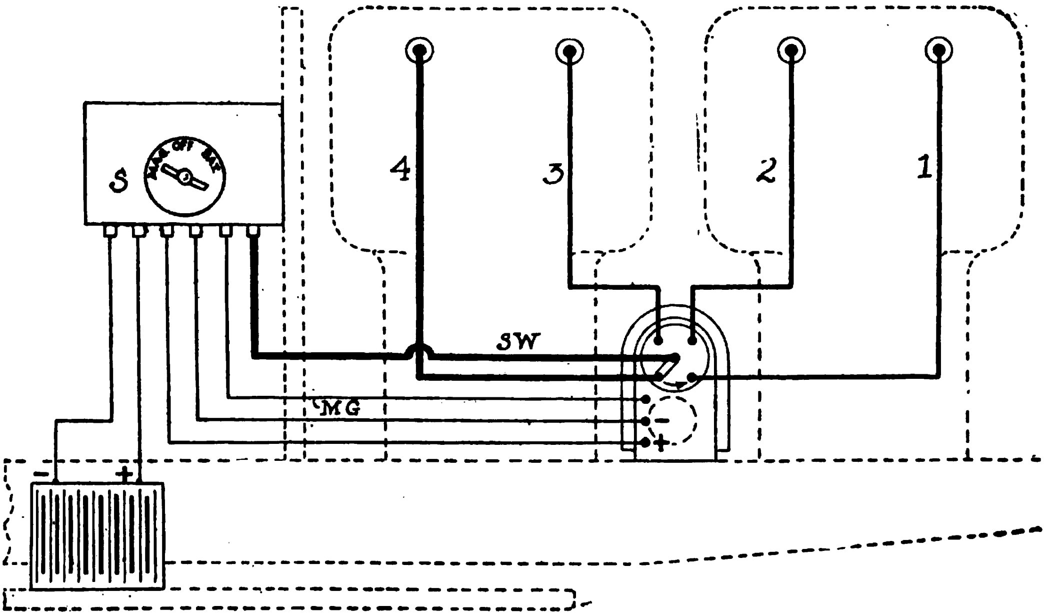


Fig. 8. A Dual System with Battery, Single-Unit Coil, Low-Tension Magneto, with H. T. Distributor on Magneto.

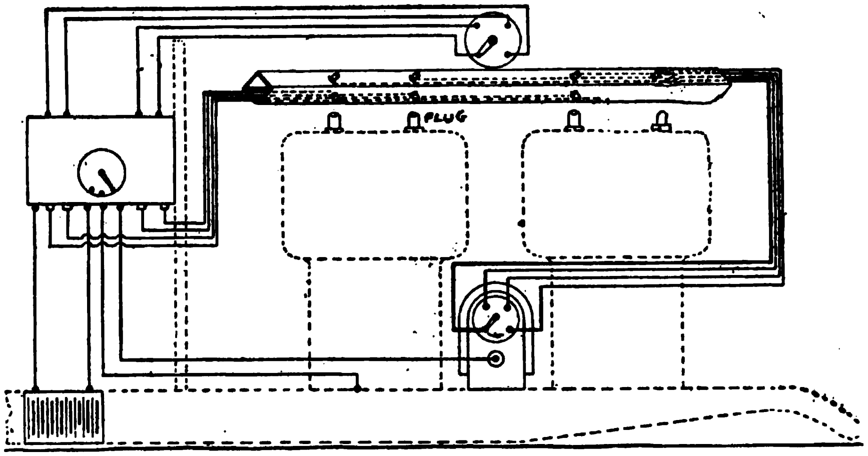


Fig. 9. A Dual System once used on Cars.

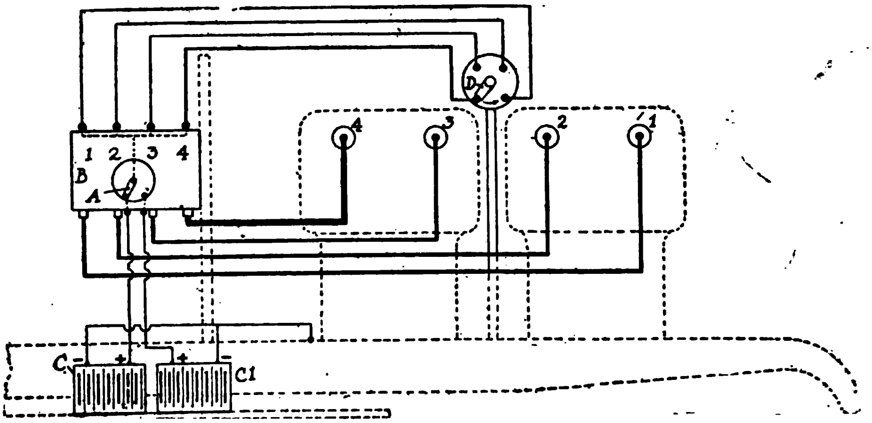


Fig. 10. Dual Ignition System with Two Storage Batteries as Sources of Current.

CHART No. 102.

metal pieces with wires connecting them to the plugs. The secondary wire from the coil carries current to an arm at the center which is rotated so that it comes opposite each of these metallic pieces just as the timer makes its contact and the secondary current is generated which allows it to jump to the nearest contact, across the very small gap. So, instead of having four coils, one coil is worked four times as much, the distributor passing the current to the proper plug. The other parts of the circuit remain just as before.

As the Exact Time at Which the Spark Takes Place in the Engine is important, the timer is so arranged that it can be rotated slightly by a small lever on the steering column or above the steering wheel, thus causing contacts to be made earlier or later in reference to the piston position in the cylinders.

FIGURE 6, CHART 101.

A Master Vibrator. Method of Wiring When a Master Vibrator is Used. This device allows a single vibrator for any number of cylinders, and by its use the difficulty of setting four or six vibrators exactly alike is obviated. It can be mounted in any convenient place on the dash or on the regular coil box. The timer wires and the secondary wires to the spark plugs are not in any way altered but a wire is carried from the battery to the master vibrator at the terminal B, and from the central terminal C the vibrator is connected to battery terminal of the coil. The magneto, or other source of ignition, if any, is connected to the other master vibrator terminal. When a master vibrator is used it takes precedence over the vibrators of the coil and the coil vibrator can be short-circuited or shunted, as shown by A in the diagram, which completely cuts them out of use.

FIGURE 7, CHART 101.

High Tension Magneto. No Coil or Battery "Fixed Point of Ignition." The Secondary Current induced in the magneto armature is now leaving the high tension distributor on the magneto and being conducted to plugs.

Wire leading from lower part of magneto goes to contact button on dash, ground, or short circuits the primary and stops the magneto.

This is the type where no coil or battery is used. The Hupmobile uses this type of ignition. There is no spark advance, the contact breaker is set to remain in one position during all variations of speed.

FIGURE 8, CHART 102.

Chart 102. Dual System With Battery, Coil and Low Tension Magneto With a High Tension Distributor. A dual system in which a storage battery and a low tension magneto furnish primary current. As may be seen position of switch on coil box, the magneto circuit is complete.

Current Leaves Wire —|— and flows through primary winding of coil, returns by wire to,—. Wire "M G" is ground wire of primary current before it passes through coil and prevents sparking at plugs, when it is desired to stop motor.

The High Tension Current From Coil is returned to revolving contact of distributor a part of the magneto.

1, 2, 3 and 4 Wires Lead to Spark Plugs. The coil is a single unit type.

FIGURE 9, CHART 102.

A Dual System Once Used. A System Which is Neither Distinctly Double Nor Dual, is shown in Fig. 9, and for want of a better title it is styled a "double dual system." It is a double system, inasmuch as there are two independent systems of current; but, as there is but one set of plugs, it is a dual system. This method of using two separate sources of high-tension current with only one set of plugs is made possible through an ingenious arrangement of the secondary or high-tension wires of both systems in a specially constructed insulating tube. The high-tension wires are attached to contacts, which protrude from the insulating tube, as designated by the dotted lines; and the tube itself is so suspended over the cylinders that it may be rocked back and forth in a manner which permits of switching the protruding contacts of either system, into connection with the plugs.

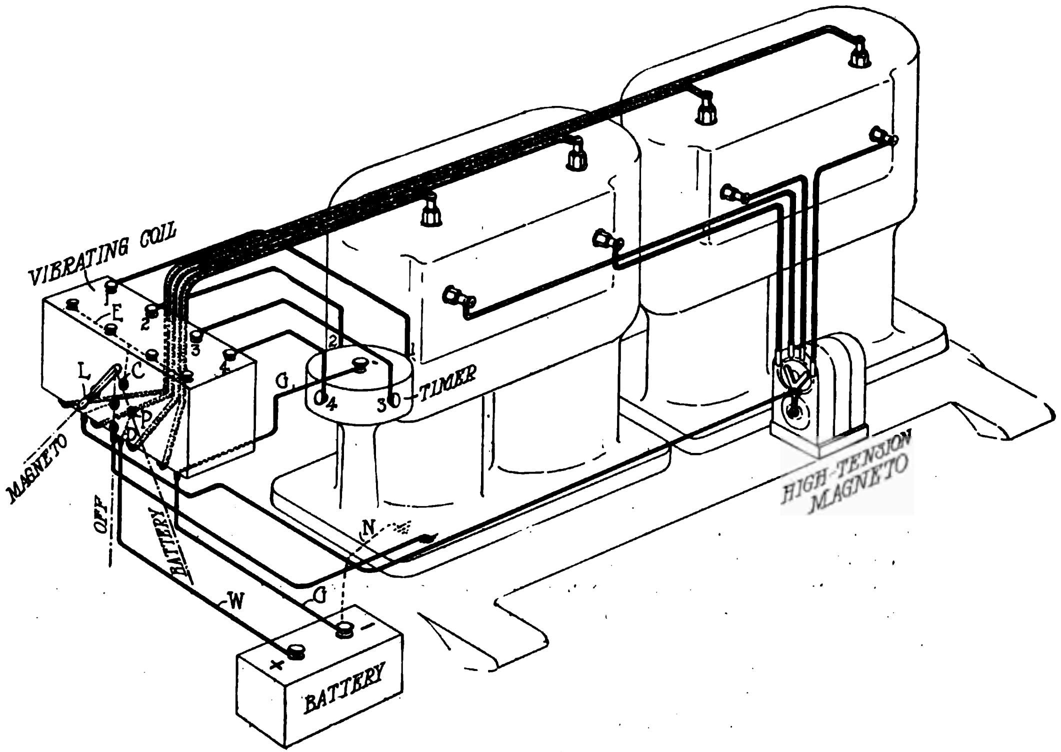


Fig. 1. Wiring Diagram of a Double System of Ignition Showing the Switch Arrangement. (Trace circuits with pencil.)

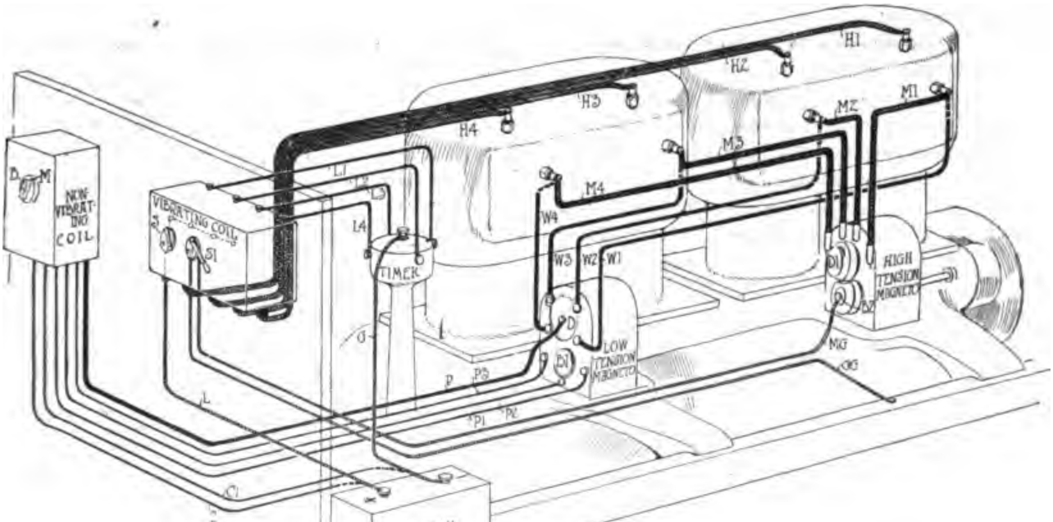


Fig. 2. Four High Tension Ignition Systems Connected to One Four Cylinder Engine Using Two Sets of Spark Plugs. (This illustration is intended to explain the various systems and how they can be used in combination.)

CHART No. 104.

FIGURE 10, CHART 102.

Dual System With 2 Storage Batteries.

A—Switch lever on coil box.

B—Current from storage battery C.

CI—Is a storage battery held in reserve.

D—Timer—Primary circuit flowing through coil 4 and a high tension current being distributed to the spark plug in fourth cylinder.

A DOUBLE SYSTEM OF IGNITION.

Fig. 1, Chart 104 Illustrates a Double High Tension System, such as is now employed on a number of makes of motor cars.

This System Consists of Two Independent Jump Spark Systems with a simple switch design for both systems.

This Switch will not permit both systems being used at the same time, although switches can be had for that purpose.

THE BATTERY AND COIL SYSTEM.

The Battery System in this diagram comprises the battery, the four-unit vibrating coil, the timer, part of the switch and wiring connections. The magneto system includes only the high-tension magneto, part of the switch and the two wires connected to the magneto side of the switch.

An Effort Has Been Made to Make the Switch and Wiring Connections as Plain as Possible so the circuits of both systems might be easily traced. **In the Battery System,** when the switch lever is moved over to the battery side, the current flows from the positive pole of the battery marked with a cross, through the wire W to a terminal on the coil; an internal wire indicated by the dotted line D leads from this terminal to a contact point P of the switch; the current then passes on through the switch lever L to the contact point C, and through an internal wire to one end of the primary winding of each coil unit, as indicated by the dotted lines E. Passing through the primary windings of one of the coil units, the current flows on to the timer, through the revolving segment of the timer, and back to the battery through the ground wire G.

The Ground Wire Does Not Necessarily Have to be Attached to the Timer, as it is in the illustration, but it is considered good practice; and often an extra ground wire is employed between the negative pole of the battery and a nut on the engine, as indicated by dotted line N. In the secondary or high-tension circuit of the battery system, the one end of the secondary winding of each coil is grounded on the primary of the coil, while the other is connected to a terminal on the bottom of the coil box; a heavily insulated cable communicates between each of these terminals and the respective spark plugs. **The engine fires 1-3-4-2,** and it will be noticed that the wires are arranged accordingly.

THE MAGNETO SYSTEM.

The Magneto Wiring System is More Simple, the wires to the spark plugs being arranged according to the firing order of the cylinders, and the wires to and from the magneto side of the switch being used merely to ground the primary current of the magneto and thereby prevent the generation or induction of its secondary, thus cutting out the sparking of the magneto system.

FOUR HIGH TENSION IGNITION SYSTEM AND TWO SETS OF SPARK PLUGS ON ONE FOUR CYLINDER ENGINE.

In Order to Further Explain the Various Systems of Ignition, and how they can be used in combination, the drawing, Fig. 2, Chart 104, was prepared accordingly.

This System is Not in Actual Use, but it is intended to show how the different systems can be used.

HIGH TENSION MAGNETO.

First: We have a High Tension Magneto operating through switch on dash Coil SI. If this lever is thrown to the left with all other switches "off," this High Tension Magneto System will supply current for the lower set of spark plugs. (Trace the circuit with a pencil.)

HIGH TENSION COIL, BATTERY AND TIMER SYSTEM.

Second: If switch S is thrown to the left the four cylinder vibrating coil will spark the plugs H1 to H4. The Battery will supply the electric current. The Timer will control the time of sparking each cylinder.

NON-VIBRATING COIL, BATTERY, CONTACT AND BREAKER ON MAGNETO AND DISTRIBUTOR.

Third: If switch on the Non-Vibrator Coil is on B, the Battery will supply electric current, passing through the primary winding of the Non-Vibrating Coil. The secondary circuit from this coil will be distributed to spark plugs W1 to W4, through the Distributor D on the Low Tension Magneto. The Contact Breaker B1 will act instead of Vibrator.

NON-VIBRATING COIL, LOW TENSION MAGNETO, DISTRIBUTOR.

Fourth: If the switch is on M, on the Non-Vibrating Coil, the Low Tension Magneto will pass its current through this Non-Vibrating Coil, increase it to high pressure and then distribute the High Pressure or Secondary Current through Distributor D to plugs W1 to W4, the Contact Breaker B1 acting as a vibrator.

EXPLANATION OF BOSCH DUAL HIGH TENSION SYSTEM OF IGNITION. .(SEE CHART 103.)

Connections Between the Coil C, on the dashboard, the Magneto M, and the Battery B1 or B2, if a reserve battery is available, should be from No. 1 on the magneto and No. 1 on the battery to No. 1 on the connection plate of the coil C, which is given diagrammatically just below.

The Magneto is so Contrived that a suitable interrupter is incorporated into the mechanism and a form of step-upt ransformer is made to do double duty, serving primarily to spark the latent charge in a cylinder in the act of starting the motor from the seat, and in case the magneto should become deranged, the same coil may br brought into play to serve as a substitute sparking system.

The Magneto is Installed in the Usual Way, and although the wiring and connections are different, as will be shown, even so the problem is berefe of complexity, and a so-called clean dash is one of the advantages realized.

The Unit Coil, which is of a shape to fit snugly in a circular housing of metal, is so encased as to be water-tight, and the condenser, trembler and switch are included within the housing.

The Switch is so Made and connected as to enable the operator of the car to switch from the magneto to the coil and vice versa.

The Dual System Magneto differs from all others of the same make in that a battery interrupter is added and the connections are altered to suit the occasion.

Neglecting the Parts which are required to compose a complete and perfect mechanism, it remains to be observed that there are two separate sets of contacts, each perfectly independent of the other, and either set may be used without the other; nor does it matter if one is out of order—the other will work perfectly in the meantime.

The Battery Contact System, used to interrupt the current flowing from the battery, is complete and is shown on the magneto (fig. 2).

There Are One or Two Little Details that stand in the way of a perfectly clear understanding of this situation, and those who understand that a coil with a trembler will deliver a spark have only to remember that the Bosch coil, as used in the dual system, is a trembler coil when the button is pressed, and a step-up transformer at all other times.

As a Step-up Transformer it receives its intermittent current in the primary winding, from the battery, to be sure, but the system of wiring is so contrived that the battery current is interrupted by the battery interrupter.

Starting on the Switch Without Cranking is one of the chief objects of this system.

A Supply of Gas must therefore be in the cylinders. **Hence, always stop** by throwing the ignition switch and not by closing the throttle so that the cylinders will draw in a charge of gas.

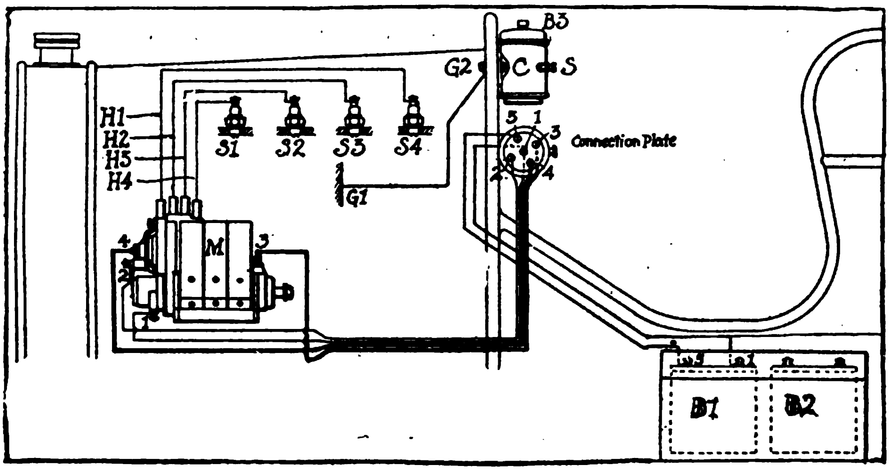


Fig. 1—Diagram of Wiring of the Bosch Dual Ignition System, Showing the Magneto, Spark Plugs, Dash Coil, Wiring Connections and Battery

M—High Tension Magneto.

C—Dash Coil.

B1 and B2—Battery.

H1 to H4—High tension cables to Plugs

S1 to S4—Spark Plugs.

The connection plate fits to the bottom of the coil, but is shown detached in order to explain how the wires are attached.

G1 to G2—Ground Wires.

S—Switch. B3—Push Button for starting engine on compression.

Explanation

The above illustration shows the Bosch dual ignition system, operating one set of sparking plugs. A special induction coil is used. This has a vibrator which can be brought into action for starting by pressing the button on coil B3. For continuous running the coil acts without the vibrator through a separate timer (see Fig. 2) on the magneto. The high tension distributor on the magneto serves for either the coil or magneto high-tension current. The change-over is made at the two-way switch on the coil.

Connections

The wiring diagram of this system is shown in Fig. 1. It will be noted that while the Independent magneto requires but one switch wire in addition to the cables between the distributor and spark plug, the Dual system requires four connections between the magneto and the switch; two of these are high tension, and consist of wire No. 3, by which the high tension current from the magneto is led to the switch contact, and wire No. 4, by which the high tension current from either magneto or battery goes to the distributor. Wire No. 1 is low tension, and conducts the battery current from the primary winding of the coil to the primary timer on magneto. Low tension wire No. 2 is the short circuiting wire by which the primary circuit of the magneto is grounded when the switch is thrown to the off or to the battery position. Wire No. 5 leads from the negative terminal of the battery to the coil, and the positive terminal of the battery is grounded by wire No. 7; a second ground wire No. 6 is connected to the coil terminal.

DIAGRAM OF THE BOSCH DUAL HIGH TENSION IGNITION SYSTEM

CHART No. 103

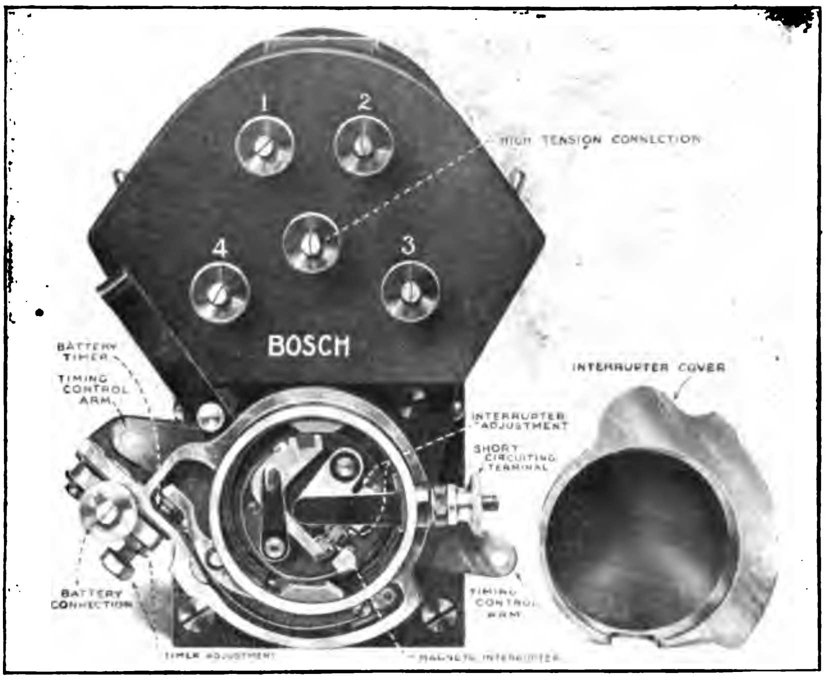


Fig. 2—Photo-illustration showing Front end of the Bosch Dual Type of Magneto.

Note that in addition to the usual interrupter a timer is also provided. This timer obviates the necessity of having one on the cam shaft.

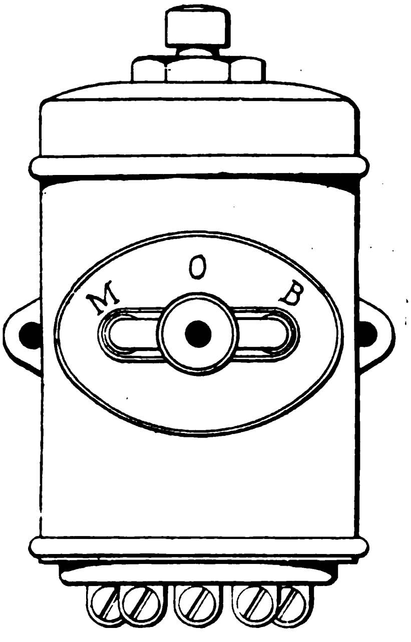


Fig. 3—General Appearance of the Dash Coil, and the Switch in Front

When the switch is on B the battery Bl and core C are connected. When switch is on M the magneto is connected. When switch is on O the ignition is cut off entirely

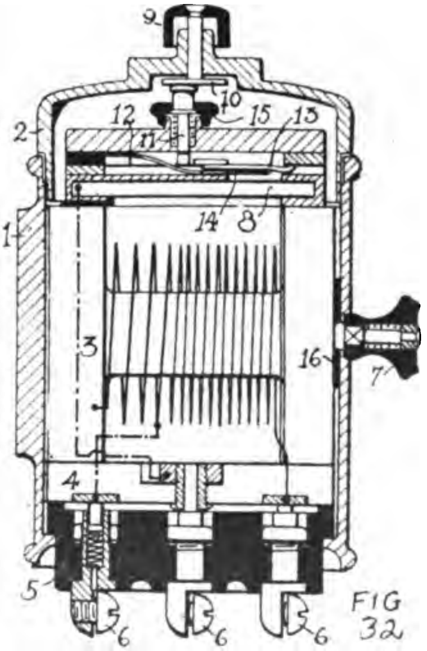
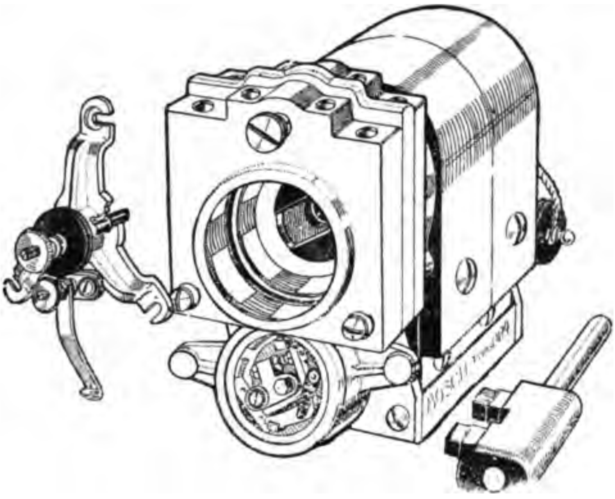


Fig. 4—Sectional View of the Dash Coil

In this illustration 1 is the cylindrical housing for the coil with its cover cap 2. Within the housing is the soft iron core 3, around which the winding is placed, as shown. The condenser 8 works in connection with the coil. S7 is the switch handle, which protrudes from the coil. 4 is the connection plate at the base with which the connections 6 attach. The vibrator parts are shown in the top, 9 marking the press button, 12 the vibrator spring, and 11 the pin for setting the vibrator working.

ILLUSTRATION OF THE BOSCH DUAL MAGNETO AND HIGH TENSION COIL

CHART No. 103A



View of Bosch two-spark Magneto, showing interior o the double distributor. The rotating arm with two carbon brushes is seen attached on the right. The separate high-tension connection and carbon brush for the distributor is in the center of the cover clamp.

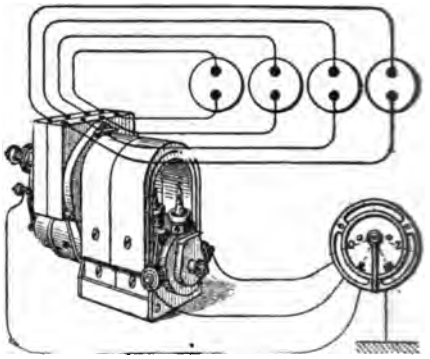


Diagram of connections of new Bosch Magneto, showing double set of plugs and switch, enabling a single or double set to be used.

The New "Double-Spark" Magneto,

The firing of the explosive charge simultaneously at two places in the combustion chamber from a single magneto has proven to be advantageous in many ways.

It has been proved that by firing the charge from two places the amount of "advance" that has usually to be given to the ignition is reduced by fully one-half, which means that, for all practical purposes, the timing point can be "fixed" without any risk of back-firing when starting, and at the same time the highest degree of efficiency obtained at any speed, because of the increased rapidity of ignition of the charge resulting.

The actual efficiency obtained is in fact, appreciably greater than from a single ignition, as tests of the two systems have proved. One explanation of this gain is that the heat losses are fewer because of the shortened period of combustion of the explosive mixture. The solution of this two-spark problem has been effected by the Bosch Company in a very simple way A casual glance at the new magneto does not reveal any marked difference in design to that of the standard pattern machine. The magnets, armature, pole-pieces, contact make-and-break are, in fact, identical; there is no increase in size of any part with the exception of the distributor. This is a distinct convenience, because the new machine can be accommodated in the same space approximately as the single-spark type magneto.

Briefly it may be stated that the principle of the machine is the employment of both ends of the high tension winding instead of only the outer end, to supply current. On the ordinary single-spark machine the beginning end of the high-tension winding is connected to the primary winding In this machine it is insulated and connected to the slip-ring which is made with two insulating sections, to which the two ends of the high-tension winding connect respectively. There are two carbon brushes or collectors making contact with the slip-ring; one of these conveys current direct to the distributor rotating arm in the usual manner, whilst the other one connects up to an isolated terminal fixed in the center of the distributor cover clamp

This terminal has a carbon brush attached, which presses against the outer end of the distributing arm, which is provided with an additional carbon brush, each of which engages a separate set of contacts or sectors in the distributor. Each carbon brush in the rotating arm of the distributor is highly insulated from the other by a considerable thickness of insulation. A separate set of socket connections of the usual kind is provided for the eight sparking plug cables required. This double distributor is, in fact, the only feature of the machine, apart from the windings, which may be called a departure from the standard practice.

Each high tension brush is in connection with a safety spark gap, one placed just above the slip-ring and the other behind it.

A special switch is used in conjunction with the machine. This is no larger than the ordinary switch, neither is it in any way complicated. It permits of one or both series of sparking plugs being used. For easy starting the makers recommend only one set of plugs being used, so that the full energy developed by the machine is discharged through them When the engine is running the other set can be switched into action. It is noteworthy that the ordinary single-pole sparking plugs are used with this system instead of two-pole or other special types.

CHART No. 105.

6-Cylinder "PIERCE" Diagram of Wiring

This System is what would be termed a "Double Ignition," in that it has two sets of plugs and two systems of ignition—coil and magneto.

A Synchronized (multiple unit) Autocoil is used in conjunction with the battery system only. The coil case contains six Non-Vibrator Unit Coils and a Master Vibrator. Each Non-Vibrator Unit Coil has a test key for locating troublesome Plugs and each Unit also has a Safety Gap or tell-tale device to indicate the accidental opening of the secondary circuit.

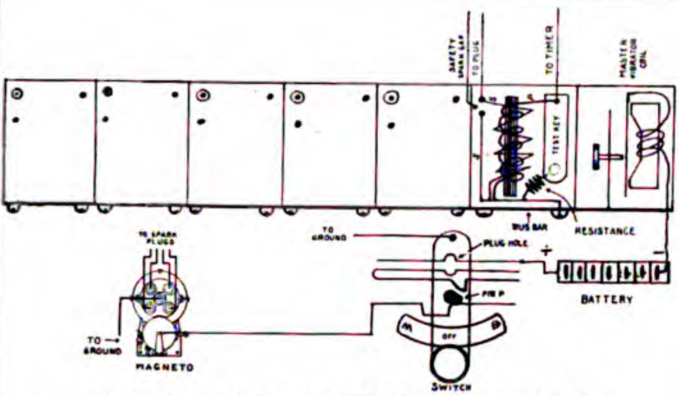


Fig. 1—Sectional diagram of the Pierce ignition system.

When Switch Lever is in "Off" Position, Magneto is grounded through Pin P to lever, and Battery circuit is open. When in B Position Magneto is still grounded and Battery circuit is closed, providing plug has been inserted in switch hole. When in M position Magneto is **not** grounded and battery circuit is open on account of Pin P being removed from spring above it.

Fig. 1 shows a complete diagrammatic circuit of the Switch, Master Vibrator and one Unit. The other five Units are identical with the one shown and are connected to the common strap along the front of the case as shown by the screws in Fig. 1 and 3.

The Test Key is normally open until it is depressed for testing, when it causes the current to flow through the resistance R and through the primary. This resistance is arranged so that there is not sufficient current passing through the primary to produce a spark in the secondary circuit; hence when the key is depressed, the spark in that particular cylinder is cut out.

Spark Gap—One side of the gap is connected to the high potential side of the secondary winding, the other to the low potential side of the secondary winding. This permits the spark to jump across the gap without doing damage to the internal construction of the coil if for any reason the wire to the spark plug should become disconnected, or the points of the plug set too far apart.

The Low Potential side of the Magneto Primary is grounded to the engine frame through the bolts which hold it in place.

The wire marked "To Ground" should run to the frame of the engine.

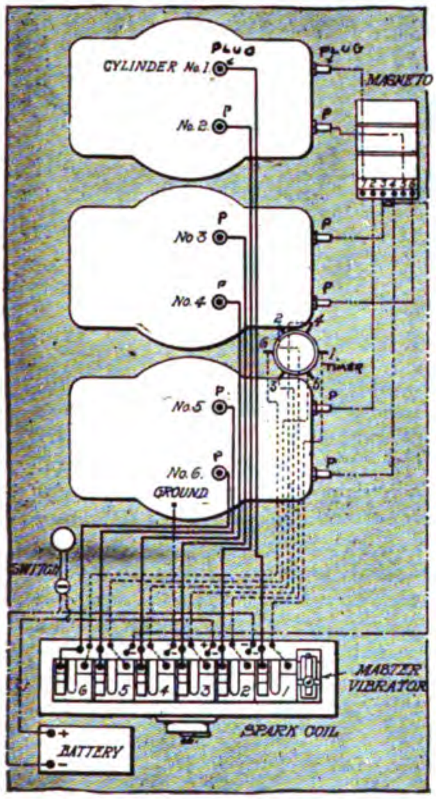


Fig. 2 View of connections from coil to cylinders and timer, and magneto to cylinders.

It is a simple matter to trace the circuit from the battery through the Master Vibrator, through one of the Coil Units, to the Timer, to Ground, whence it returns through the Ground wire, to the Switch Lever. If it is turned in the "B" position, the Magneto will be grounded and the battery circuit complete when plug is inserted in the plug hole.

The Pierce "Double" System of Ignition for Six-Cylinder Pierce Engine. The coil system being the Master Vibrator type simular to system explained in Chart 75. The Magneto system above is the usual type.

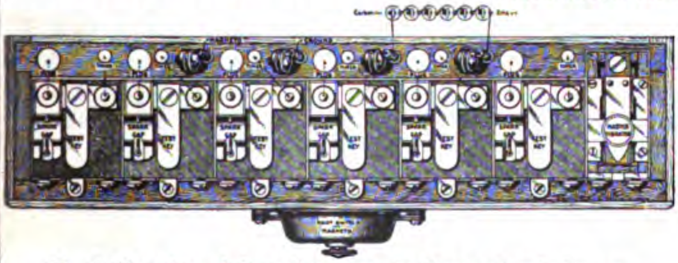
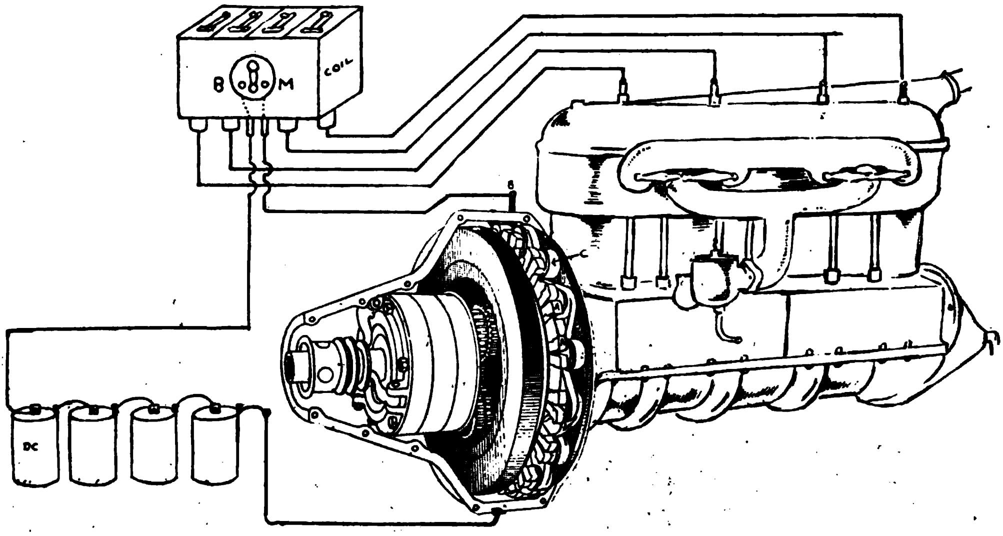


Fig. 3—Top view of the coil used on the Pierce six-cylinder car.

CHART No. 106.



Ignition Plant of the Ford.

The Ford Fly Wheel Magneto is somewhat different from the usual form of magneto. Instead of the horse shoe magnets being placed over pole pieces and the armature revolving therein, the V-shaped magnets (A) are bolted to the periphery of the fly wheel, on its forward face. These magnets are the "permanent" form of magnet. Opposite the pole tips of these permanent magnets is arranged a series of coils of thin copper tape (C), each armed as a soft iron core supported in position by a stationary ring or carrier. The consecutive coils are wound in opposite directions and are connected in series, the two final ends of the series of windings being led to binding posts (B), which are in turn connected with the coil of ignition system. There are sixteen of these windings joined in series and these windings are called the armature. In this type of magneto the armature is stationary and the magnets revolve. The rotation of the permanent magnets past the poles of the coil cores, causes a very rapid building and breaking of the magnetic flux with a corresponding very rapid succession of induced electric pressures.

The current generated is alternating.

Above illustration shows the Ford ignition with a set of dry cell batteries (DC) to start with or for emergency use. When switch leaver is on B the battery supplies the current for the coil. When switch lever is on M the battery is cut out and the magneto is used for ignition.

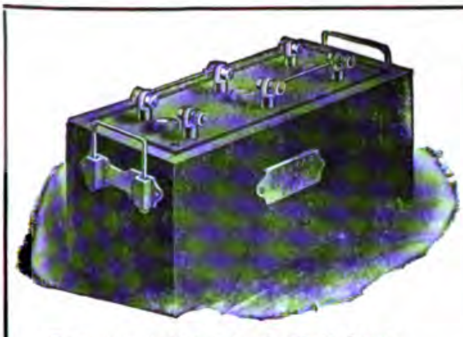


Fig. 1—A 6 Volt, 3 Cell Ignition Storage Battery, Showing Cells Connected in Series.

The terminal + is the positive terminal and the terminal – is the negative terminal.

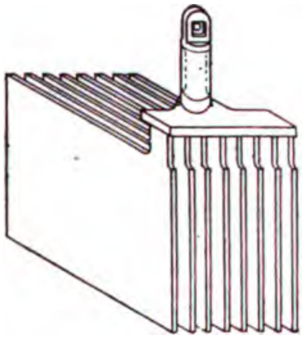


Fig. 2A—Positive Plates Assembled Ready to Place in Jar.

The negative plates are assembled in the same manner and both positive and negative plates are placed in jar. See Fig. 2.

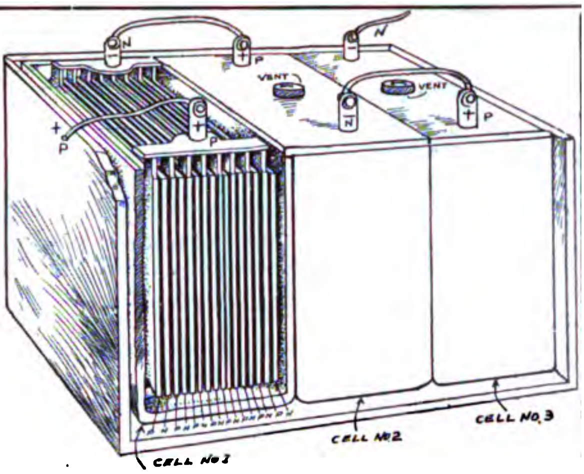


Fig. 2—Showing the 3 Cells, Each Containing a Set of Positive Plates and a Set of Negative Plates.

Each cell gives but two volts pressure, no matter how large or how small.

The amperage or quantity of current each cell will discharge per hour, however, depends entirely on the number of plates and size.

A positive plate is placed next to a negative plate.

A thin piece of corrugated hard rubber is placed between each plate as an insulator, so that they will not touch.

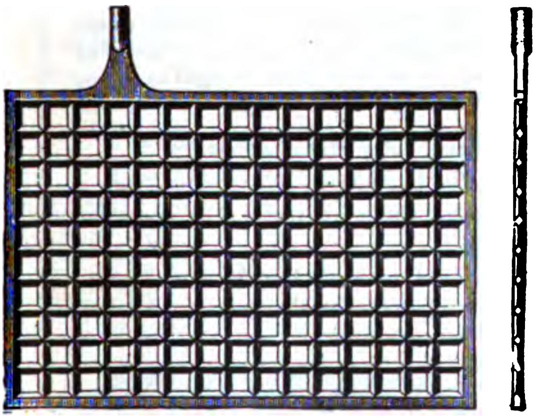
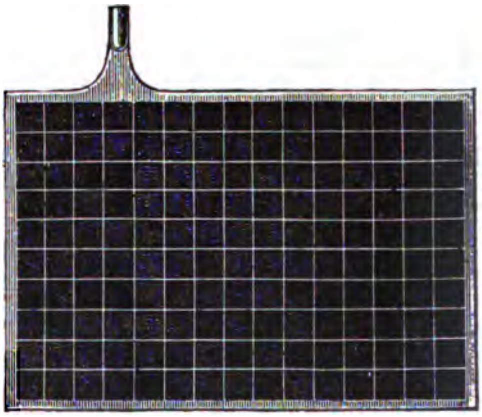


Fig. 3—Both the Positive and Negative Plates are Molded of Lead. They are cast in molds in the form of grids as shown. The object of these grids is to retain or hold a paste. The grids are filled with this paste which hardens. (This type is the Faure)



After the Grids are Filled with this Paste it has the Appearance of the Above Plate. The negative plate is filled with Litharge and the positive plate is filled with Red Lead.

Construction of the Faure Type of Storage Battery

CHART No. 111.

Forming the Plates

The plates are "formed" by immersing them in a solution of sulphuric acid, the positive plates being connected together and the negatives.

Electrical current, (Direct only) is then sent through these plates. The positive wire of the charging wires is connected to the positive or red lead plates and the negative wires to the negative or litharge plates.

The time required to form the plates requires about one week. The plates are then ready to be assembled and put into cells.

Assembly Into Cells

Fig. 5 shows the plates assembled ready to be placed into the hard rubber jar. (Fig. 6)

This is done by placing first a positive plate, then a sheet of insulation (hard rubber, perforated) then a negative plate, then another sheet of insulation, then another positive plate and so on, making the cell as large as desired.

In this cell illustrated, however, we have five positive plates and four negative plates.

After these plates are placed side by side as shown, a lead "connection plate" or strap (Fig. 9) is burned, by an electric arc, to all the positive plates, another strap is burned to all the negative plates. We then have the cell assembled as shown in Fig. 5.

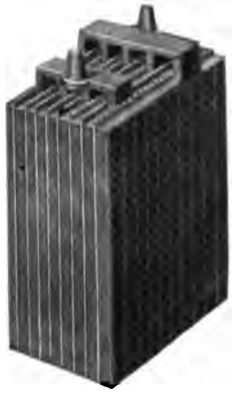


Fig. 5
Plates Assembled

Fig. 6
Hard Rubber Cell

Placing In Jar, Sealing and Charging

The Hard Rubber Cell, (Fig. 6) is then partially filled with a solution of sulphuric acid (one part sulphuric acid and two parts water) and again they are charged for about one week by having a current of electricity of very low amperage.

The Cells are then ready to seal. The hard rubber top (Fig. 7) is placed inside of the top of the hard rubber jar over the plates. The terminals, one positive and one negative, project. Melted pitch is poured around the edge of this top and the cell is sealed.

A "Vent" hole is left in the center of this top, which is plugged with a soft rubber plug (Fig. 8). This plug has a small hole in the center to allow the gas to escape and to keep the acid from splashing out.

Two or More Cells Make a Battery

A battery consists of two or more cells. Fig. 1 shows a battery, because there are three cells contained therein.

These cells are placed in a wood box, lined with pitch, and are then connected together as shown in Fig. 1.

Fig. 7
Hard Rubber Top
to Cell

Fig. 8
Vent Plug

Fig. 9
Lead Lug
Connecting Plates

INSTRUCTION No. 23

STORAGE BATTERIES:—Introduction. Principle. Construction. Re-charging. Care and Maintenance. The Electric Vehicle.

INTRODUCTION.

Storage Batteries are Described as Being Devices for Storing Electrical Energy, which may then be used for various purposes.

The Storage Battery Is Used on Automobiles for Ignition, Lighting, Operating the Electric Horn and Various Other Purposes. It is also used to supply the electric current to operate an electric motor, which, in turn, propells an electric vehicle.

Storage Batteries Are Also Called Accumulators, because they "accumulate" electric energy from an outside source. Storage batteries are also called secondary batteries.

PRINCIPLE OF THE STORAGE BATTERY.

The Accumulator (or battery, as it is often termed) consists of a set of lead grids or frames, which are filled with oxides of lead, as explained in Chart—111, these plates being immersed in dilute sulphuric acid are contained in hard rubber jars.

The Accumulator Has to be Charged by means of either a primary battery, or, what is more convenient, a dynamo.

Certain Chemical Changes Take Place in the constitution of the plates which enable a current to be drawn from them at will.

When All the Chemical Energy Stored in the plates is converted back into electricity, the battery is said to be "discharged;" but it can be re-charged again by sending an electric current into it, when the chemical change is produced again.

The Operation Can Be Repeated any number of times.

The Plates Are Different in Color, the positives (lead oxide) being a deep chocolate color, and the other set, the negatives, being grey (pure lead).

The Terminals on the outside of the jar are connecting up the accumulator to the other details of the system.

The Terminal Connected to the Positive Plates Is, as a rule, painted red to distinguish it, and to be able to connect up properly.

Very Often a Plus Mark (+) denotes the positive connection.

The Terminal Connected to the Negative Plates is generally marked with a minus mark (—) which denotes positive plate.

The Grids of an Accumulator are constructed in a special way, so that the lead oxide, or active material, is held securely in place.

To Further Assist in Keeping the Plates in Position, and resist the influences of vibration, expansion, and contraction, which tend to cause them to buckle and disintegrate, it is usual to provide celluloid or wood or vulcanite stays or separators between each pair of plates.

STORAGE BATTERY PLATES.

The Material Used for plates of storage batteries are usually made of LEAD, but some manufacturers use iron for one plate and nickel for the other, others, lead and zinc, but lead plates are used almost exclusively.

The Illustrations Fig. 2, 3, and 4, Chart III, will explain the construction and formation of the plates.

THERE ARE TWO TYPES OF PLATES.

In General the Plates May Be Divided into two classes:

THE PLANTE.

THE FAURE.

The Difference is principally in the method of constructing the plate.

THE PLANTE TYPE PLATE.

In the Plante Type, the lead is chemically attached and finally converted into lead peroxide, after going through several changes.

The Plates Are All "Formed" as Positive Plates First. To make the NEGATIVE plates the current is reversed, the peroxide being changed into SPONGE lead.

In Order to Make This Type of Plate More Efficient, and its formation more rapid, the surfaces are finely subdivided, the following methods being those most common: scoring, grooving, laminating, casting, pressing and by the use of a lead wool.

This Type of Plate Is Not Illustrated.. The plates shown are all the Faure type.

THE FAURE TYPE OF PLATE.

The Faure Type Is the Parted Type and is formed by attaching the active material (red lead and letharge) by some mechanical means to the grid proper.

This Is the Type Shown in Chart 111 and 112.

The Material Used at the Present Time by Manufacturers for Making This Paste, is supposed to be RED LEAD in the grids of the POSITIVE plates and LITHARGE in the grids of the NEGATIVE plates, however, some manufacturers use a secret process of mixing this active material.

PASTE FALLS OUT OF THE GRIDS.

There Is a Tendency for the Plates to Shed the Paste after it hardens on the grid.

"Buckling" of the Plates, meaning to expand from sudden high discharges and other causes, will often cause the active material (paste) to loosen and fall out of the grids and go to the bottom of the jar and "short circuit" one plate to the other.

Many Ways Have Been Tried for Mechanically Holding the Active Material or Paste to the Grid, the general method being by a special design in the shape of the grid.

Some of These Designs Are Solid Perforated Sheets or Lattice Work; corrugated and solid recess plates not perforated; ribbed plates with projecting portions; grid cast around active material; lead envelopes; triangular troughs as horizontal ribs.

ACTION OF THE STORAGE BATTERY.

Storage Batteries Embody several separate cells conveniently combined in one packing case. (See Fig. 2, Chart 111.)

Each Cell or Single Battery Consists of a group of positive plates inter-leaved between a group of negative plates.

The Plates are spaced apart by insulating separators.

The Elements So Made are immersed in electrolyte (pure sulphuric acid diluted with pure water).

In a Charged State the active material on the positive plates is lead peroxide or oxidized lead.

The Material on the Negative Plates is porous lead sponge free from oxygen.

When the Battery Discharges, or does work some of the sulphuric acid in the electrolyte chemically unites with the material on the positive plates and negative plates.

At the Same Time That This Acid is Abstracted, water is formed so that as the discharge continues the strength of the electrolyte grows less, which is shown by the density, measured by hydrometer.

DISCHARGE REACTION.

After the Battery Has Done Its Work, charging the battery breaks up the compound formed on each plate, and absorbing water from the electrolyte and restoring sulphuric acid to it ultimately leaves nothing but lead peroxide on the positive and sponge lead on the negative. Nothing whatever is used up except the current.

REACTION AT THE PLATES.

The Water in the Electrolyte May Have Evaporated; the sulphuric acid never does.

Unless the Electrolyte is Spilled or comes out as spray it is never necessary to add any sulphuric acid.

The Quantity Originally in the Cell Does Not Need to be Replenished; it is not used up.

On the Other Hand, as the water contained in the electrolyte evaporates, it is necessary to replenish with distilled water occasionally, so as to keep up the level of the liquid.

Any Impurities That the Water Contains are left behind in the cells by the evaporation of the water.

Impurities Will Become Concentrated in the Cell unless the water used is chemically pure, distilled water.

If This Is Unobtainable, use good drinking water, free from iron, salt or chlorine.

CAPACITY OF A BATTERY.

The Capacity of a Battery Is Measured in Ampere Hours.. The volume of a current flow is measured in amperes.

A Current of One Ampere Flowing for One Hour is the unit by which capacity is measured, and is called ampere hour.

A Fifty (50) Ampere Hour Battery is rated to give one ampere for 50 hours.

A Sixty (60) Ampere Hour battery is rated to give one ampere for 60 hours.

A One Hundred (100) ampere hour Battery is rated to give one ampere for 100 hours.

HOW TO GET THE GREATEST MILEAGE.

The Mileage Obtainable From a Battery depends upon the amount of current consumed by the coil and the capacity or quantity of electricity in the battery; lowering the consumption and increasing the capacity of the battery increases the mileage capacity.

The Capacity of a Battery Is Independent of its electrical pressure.

A 3-Cell Battery Gives Six Volts, no matter what the size of the cell, but the length of time it will maintain a certain current out of it depends on the capacity or electrical size of a battery, an ordinary jump spark coil requires about one ampere per hour, therefore a 60-ampere hour battery would operate for 60 hours.

BEST SIZE OF BATTERY TO USE.

A One Hundred (100) Ampere Hour Battery will, with one charge, run a car nearly twice as far as a 60-ampere hour battery.

The Saving in Fees for Charging is correspondingly reduced.

Therefore, unless the battery box is too small, the use of this size battery is recommended as being the best size and yet not too large for convenience or too heavy to handle.

Nothing Smaller Than a 50-Ampere Hour Should Be Used when only one battery is carried on a car.

A Very Convenient Arrangement Is to Use Two Batteries, one of which is held in reserve, while the other is running the car.

Two 60-Ampere Hour Batteries, or one hundred for running and one fifty for reserve, are a good combination.

By Having Two Batteries the motorist is assured of ignition current at all times.

One Battery May Be Left to Be Charged While the Other Is Used for running without any inconvenience.

For Use in Conjunction With a Magneto, the fifty (50) hour and 60-ampere hour are convenient adjuncts, always ready in emergency in case the magneto is out of order.

IMPORTANCE OF CLEANLINESS.

The First Necessity Is Cleanliness.. There is nothing that more easily provides a short circuit and causes a leakage of the current than accumulation of dust and many other kindred types of matter.

When Such are Permitted to Remain on the Top of the Cells they become saturated with the moisture which inadvertently sprays from the cell or cells while charging, and thus form an excellent bypass from positive to negative terminals, and in a very short time entirely empty the battery.

Again, This Moisture Is Permitted to Attack the Terminals of the Battery, and these being generally made of brass or similar metal are easily attacked and CORRODED so that they are immovable and sometimes entirely enveloped by a heavy coating of blue crystals of sulphate of copper.

This Salt Is Readily Soluble in Water and Acids, and if allowed to get into the electrolyte of the battery is fatal to the life of the same.

Yet How Often Is This Salt Washed Off With Water, or removed by other methods, and allowed to fall into the cells?

It Is Well to Keep the Terminals Coated With Vaseline or Thick Grease and so prevent corrosion.

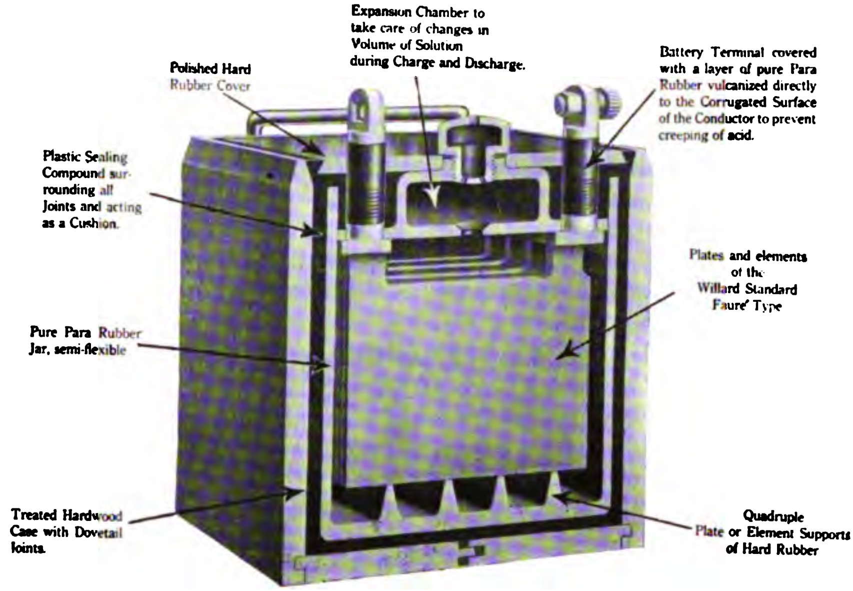

Expansion Chamber to take care of changes in Volume of Solution during Charge and Discharge.
Polished Hard Rubber Cover
Battery Terminal covered with a layer of pure Para Rubber vulcanized directly to the Corrugated Surface of the Conductor to prevent creeping of acid.
Plastic Sealing Compound surrounding all Joints and acting as a Cushion.
Plates and elements of the Willard Standard Fauré Type
Pure Para Rubber Jar, semi-flexible
Treated Hardwood Case with Dovetail Joints.
Quadruple Plate or Element Supports of Hard Rubber

Fig. 1—Method Employed by one Manufacturer in Placing the Plates in the Hard Rubber Jar and the Jars in a Wood Box.

Note extra precaution is taken to avoid vibration. Also note the plates do not rest flat upon the bottom of the hard rubber jar but are held up on ridges.

A Hydrometer is Important for Testing the condition of the charge of the battery. One manufacturer gives the following scale to indicate the condition:

About 80% of charge is left when guage indicates 1225
About 60% of charge is left when guage indicates 1200
About 40% of charge is left when guage indicates 1175
About 20% of charge is left when guage indicates 1150
Practically exhausted when guage indicates 1125

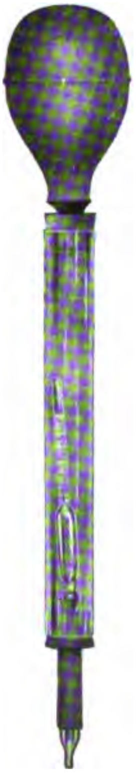


Fig. 2
Hydrometer Inside of a Bulb Syringe.

The bulb syringe is inserted in one of the vent holes of the cell. The acid is drawn into the tube. The hydrometer inside of this tube will float.

A scale of figures is graduated in the upper portion of hydrometer.

The level of the acid with the scale indicates the gravity of the acid.

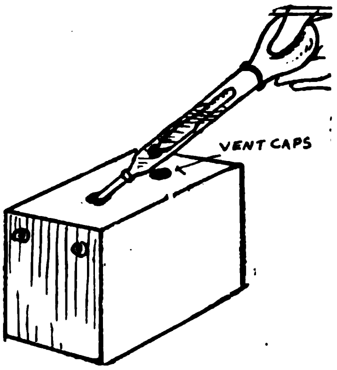


Fig. 3
Showing How the Hydrometer and Bulb Syringe is Used

While the Growth of the Sulphate does commence to form at once when the electrolyte comes in contact with the terminals, its screws or nuts, it does not grow, or accumulate, in one day, or even in several days, to an alarming extent, but usually takes weeks to develop.

Just a Few Minutes, Once a Week, Will Suffice to Clean Up a Battery, and so comply with the first and most necessary rule.

When the Electrolyte, or acid is below the plates, this part of plate is exposed or out of the liquid and a sulphation occurs of such a nature as to damage the plates irreparably, besides that part of exposed surface is inactive and useless.

Never Add Sulphuric Acid to the Cells to Compensate Loss, unless such loss has been caused by a spilling of the acid, and then first ascertain the specific gravity of the acid remaining in the cells and make up with diluted acid of the corresponding specific gravity till the plates are again covered.

In All Cases of Adding To, or Compensating Evaporation Losses (except as above stated) nothing should be used but pure distilled water and absolutely pure and clean acid.

A Healthy Battery Used Continuously Should Not Require Any Addition More Than Once a Year, but will probably require pure water at least once a week, if not more often.

HYDROMETER TESTS.

Provide Yourself With a Hydrometer to Enable You to Test Your Electrolyte and Acids Periodically, and you will avoid a great deal of trouble. (See Chart No. 113, Fig. 2 and 3.)

It May Be Said that the condition of the specific gravity is the pulse of the cell, and certainly it is the one means of ascertaining the condition of health of the cell or battery.

Let Us Suppose That the Specific Gravity of the Electrolyte as given by the maker of the battery is to be maintained at 1.250 degrees, at a temperature of sixty degrees Fahrenheit, when fully charged and cell in thorough working condition. They apply the following:

At the End of the Complete Discharge the gravity will read somewhere about 1,150 degrees. If only about half discharged, then about 1.200 degrees. If only one-quarter, 1.225, or three-quarters, 1.175 degrees, so that one may arrange a scale whereby the amount of charge used, or that remaining in the cells, may be estimated.

On Recharging, the specific gravity will rise from its reading of 1.150, or whatever it may be, to that of 1.250 again, thereby indicating the cell has received its full charge.

In Cases Where the Specific Gravity Will Not Show Any Rise During or at the End of Its Charge, it indicates a short circuit, and the cell has not received its charge.

In Cases Where the Specific Gravity Comes Up to 1.250 at the End of Its Charge, but falls to a lower figure during a period of idleness or standing for say twenty-four to forty-eight hours this also indicates a short circuit, or else local action (or internal discharge), due to contamination of the electrolyte by some impurity.

Thus, We See That the Hydrometer is Really an Essential Equipment for all owners of batteries, and its small cost will well repay for itself.

If the Electrolyte Is Low in Specific Gravity, assuming that there are no short circuits, due to sediment or other cause, it is evidence:

First, of sloppage or a leaky jar, the loss having been replaced with water alone; in which case it should be allowed to fall to 1.250 when fully charged; then gradually restored to normal by addition of 1.275 specific gravity electrolyte when replacing evaporation.

Second, of insufficient charge, overdischarge, standing in a discharged condition or a combination of these abuses; any of which mean that there is acid in combination with the plates, which should be brought out into the electrolyte by a long charge at quarter the normal discharge rate. Continue charging until the gravity of the electrolyte stops rising; then adjust to normal, 1.270 to 1.280, by drawing off some of the electrolyte and adding water if it is above normal, and by adding acid if it is below normal.

Very Complete Instruction Books are Generally Supplied for the Asking, by the Manufacturers of batteries, which you would find both interesting and instructive.

It Is Also Advisable for an Owner of a Storage Battery to take it to some one who makes a specialty of charging.

Never, on Any Account, Discharge Your Battery Below 1.8 Volts Per Cell, because it develops a condition of chemical natures that is not easily remedied.

To Ascertain This It Is Necessary to Have a Small Pocket Voltmeter reading from say O-3 volts.

These Are Very Inexpensive and will, if used, greatly prolong the life of your battery by helping you to know when the battery has fulfilled its functions.

It Is the Greatest Defect That a Battery Has, That It Cannot Give Warning, Groan or in Some Way Protest Against Being Overworked, like most other appliances, but it is so meek, modest and humble that it continues to do its best for its owner until it utterly collapses with fatigue, and like the old proverb, it usually becomes a good horse worked to death.

VOLTAGE TESTS.

The Normal Voltage of the Storage Battery is 2.0 Per Cell when doing no work, which is, if the electrolyte be 1.250 gravity, usually raised to about 2.10 volts.

The Storage Battery, Unless Worked Below 1.80 Volts has a recuperative power of raising from 1.80 volt to the normal 2.0 to 2.10 volts within a few minutes after the discharge current has been discontinued.

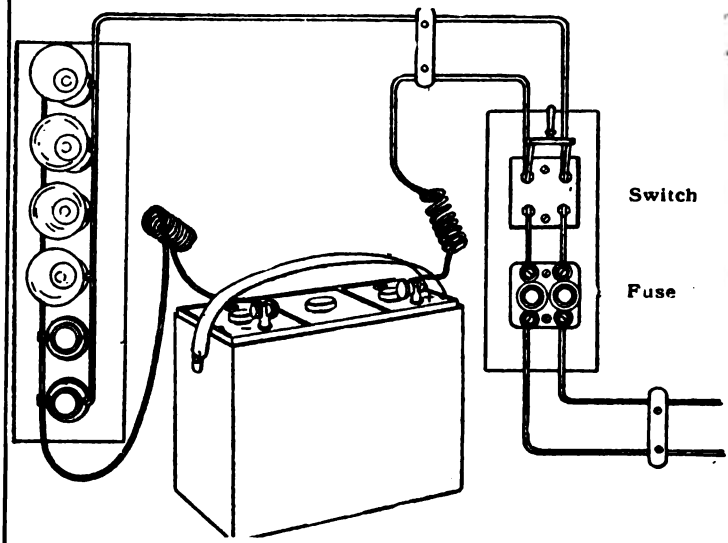
This Act Has Often Led Many Users Astray as to their opinion of the condition of their cells.

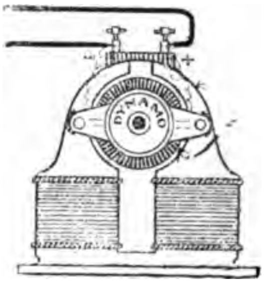
For Instance, suppose one to be out with his car, and the spark is not sufficiently strong to give satisfactory ignition of the gases; he stops to locate the defect.

Usually the First Thought Is, are the batteries right?

The Voltmeter Is Taken and Put to the Cells and because they read 2.0 to 2.10 they are deemed all good.

Whereas, if the reading had been taken with a small current passing, the voltmeter would probably have read 1.5 volt or perhaps less per cell.





Direct Current Dynamo Usual Source of Electricity for Charging a Storage Battery

A Simple Method for Charging a Storage Battery from a "Direct" Current Light Circuit.

The diagram above plainly shows the method of connection.

Let us assume that the battery to be charged is a six-volt, 60 ampere-hour battery, and the rate of charge given by the manufacturer is five amperes per hour.

Also assume that the lighting circuit from which the current is obtained is a 110 volt circuit.

In this instance a 16 candlepower light connected to this circuit will consume ½ ampere of current per hour, therefore by making a bank of 10 lights, connected in parallel as shown (only four shown here) when all ten are lighted, the battery will receive five amperes of current as each light draws one-half an ampere.

To reduce or increase this amperage charge, extra sockets can be provided and lamps added or taken out.

For instance; if 10 lights are used, the charging rate would be five amperes per hour, therefore it would take 12 hours to charge the battery because the battery is a 60 ampere-hour capacity battery.

If only four lights were used, then the charging rate would be only two amperes per hour and it would take 30 hours to charge.

To test the battery with a volt meter, turn on all ten lamps and connect a volt meter to battery terminals. When the volt meter shows 7½ volts the battery is fully charged.

To test the battery without the charging current flowing, turn off the switch and press the button, the voltmeter will then indicate 6½ volts.

Never press the button with the switch turned on and the battery disconnected, as the voltmeter will then receive 110 volts, which will injure it.

Don't fail to connect the positive pole of the battery to the positive wire of the circuit and the negative to the negative terminal of battery.

Before connecting the electric light wires to the battery, test them for polarity by holding the two wires about one inch apart in a glass of water with about a spoonful of acid in it, with the lamps turned on. The wire from which the bubbles arise is the negative pole. This wire should lead to the binding posts marked —, of the battery.

Positive pole on battery is marked + and the negative pole is marked —.

Charging a Storage Battery with Direct Current

CHART No. 114.

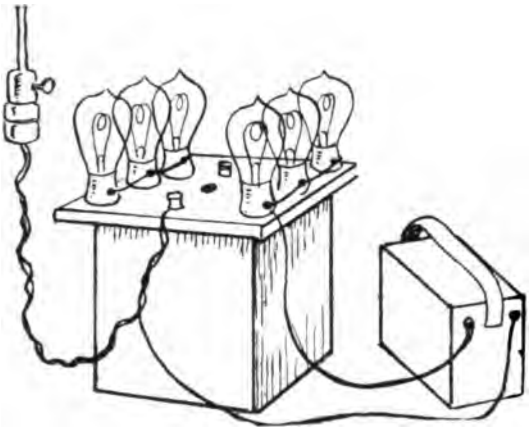


Fig. 1—An Alternating Current Rectifier; Making it Possible to Charge a Storage Battery From An Alternating Current

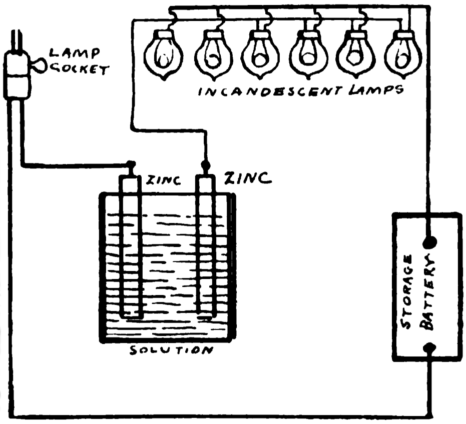


Fig. 2—Diagram of Connection of the Alternating Current Rectifier

Method for Charging a Storage Battery from an Alternating Current Circuit.

Only Direct Current is suitable for charging a storage battery as per Chart 114. Direct current is seldom used for public lighting plants and we find it only in private electric light plants where the current is not carried very far from the dynamo. The current used by public lighting plants is generally "alternating."

This Being the Case very few people have access to only the current as usually furnished in their own homes which is invariably an alternating current.

Alternating Current Will Not Charge a Storage Battery without a RECTIFIER, that is; some means to convert it into DIRECT current, which is the object of this chart.

By observing Fig. 1 we have practically the same method as employed in the direct current method, excepting the current must be passed through an acidulated solution of water and acid. The object in this is to convert the alternating current into a direct flow of current.

This process consists of a stone jar containing a solution of water and acid with two zinc plates immersed therein and placed in series with the bank of lights.

The resistance is greater or less according to the distance the plates are from each other.

The same principle as to the number of lights for rate of charge applies to this system just the same as in the explanation in Chart No. 114.

Charging a Storage Battery from Alternating Current

CHART No. 115

In This Way It Often Occurs that much time has been lost in going over the car looking for the defect while all the time it has been the batteries which have innocently showed 2.0 volts because they were standing idle.

Unless a Current Is Passing, say one-half to one ampere, the voltmeter reading is useless.

Another Method is to simply connect a small, 6-volt hand electric lamp while engine is running or the current is being used. If the light is white, the battery is charged, but if yellow or dim it needs recharging.

TO BE OBSERVED IN CHARGING.

The Storage Battery Should Not Be Allowed to Stand for Any Length of Time Uncharged. Remove the vent cap occasionally and make sure the electrolyte or solution comes at least ¼ in. above the tops of the plates. If lower, distilled water should be added in sufficient amount. The electrolyte should show a hydrometer test of 1.275 or 1.250 when the battery is fully charged and 1.150 when the battery is discharged.

Before Putting New Solution Into the Battery, Charge it at the usual rate or not exceeding five amperes per hour until it gases freely. Then empty out the old electrolyte and add the new solution until it reaches the proper height.

HOW TO MAKE ELECTROLYTE.

Electrolyte Can Be Made by adding chemically pure sulphuric acid to distilled water (pour the acid into the water) using 6 oz. of acid to 8½ oz. of water by weight. The battery should never be allowed to fully run down as it is detrimental.

HOW TO FIND POSITIVE AND NEGATIVE TERMINALS OF CHARGING WIRES.

Connect the Positive Terminal of the charging line to the positive terminal of the battery which is marked and the negative to the negative terminal.

In Lieu of Any Other Device the Positive Wire of the Charging Line May Be Found by holding the bare ends of the charging wires about 1 inch apart in a glass of water to which a small amount of salt or a little sulphuric acid has been added.

Do Not Allow the Wires to Touch. The Wire at Which the Greatest Number of Bubbles Arise is the negative one.

CHARGING WITH INCANDESCENT LAMPS, NUMBER TO USE.

One 16 candle power, 110 volt lamp lets through ½ ampere of current.

One 32 c. p. 110 volt lamp lets through 1 ampere of current.

Six 32 c. p. 110 volt lamps will let through 6 amperes of current.

A 100 candle power lamp on a 110 volt circuit will allow about three amperes of current to flow.

Charging rate for 6 Volt 60 Ampere battery, 3 amperes for 20 hours (use 3-32 c. p. lamps).

Charging rate for 6 Volt 80 Ampere Battery, 4 amperes for 20 hours (use 3-50 c. p. lamps).

POINTERS.

A Storage Battery Should Have a Slight Overcharge about once per month. In overcharging the temperature should be carefully watched and not allowed to go over 100 degrees Fahrenheit.

When the Battery is Being Charged as it approaches full charge it will begin to gas freely. The charging should usually be continued one hour after this.

When Fully Charged With the Current Still On the voltage from each cell will be about 2½, and if 3 cells, (which is the usual number for an ignition battery) the voltage will be 7½ volts.

Voltage Readings Should Always Be Taken when charging or discharging.

After Use, the cell should be recharged when the voltage drops as low as 1 8-10.

However, there are objections to using instruments on a storage battery; in fact, there is no real way of telling exactly how much is in a storage battery as it retains its voltage practically the same almost until the end of the discharge and then drops off rapidly.

If Allowed to Stand for a While After Being Completely Discharged it will often recuperate enough to show a good voltage although there is practically no current back of it.

The Ammeter Produces a Dead Short Circuit and shows what the battery will deliver on a short circuit but it is injurious and the ammeter should be used sparingly.

The Specific Gravity Test is the only safe way.

TWENTY-EIGHT STORAGE BATTERY SUGGESTIONS

Manufacturers Usually Furnish Explicit Directions as to care and operation of their storage batteries and these should be carefully adhered to. The following directions, however, may assist the beginner:

(1) **Learn to Prepare the Electrolyte.** Use a large earthen crock or lead vessel with burnt seams. One part of chemically pure concentrated sulphuric acid is mixed with several parts of water, the proportion of water varying with the type of cell, from three parts to eight parts. Specific gravity of a suitable acid 1.76.

(2) **Always Pour the Acid** into the water, never the reverse.

(3) **Use Pure Water** either distilled or rain water.

(4) **Allow the Electrolyte to Cool** before placing in the cells. The specific gravity should be 1.200 or 25 degrees Baume. Add distilled water if a higher reading is obtained.

(5) **Grids Should Always Be at Least ½ Inch Below the Surface** of the solution.

(6) **Woolen Clothing Is Little Affected** by acid.

(7) **Ammonia Immediately Applied to a Splash of Acid on the Clothes Neutralizes** the acid and prevents a hole being burnt in the material.

(8) **In Case a Bit of Acid Splashes Into the Eye** wash well with warm water and put into the eye a drop of olive oil.

(9) **Avoid the Use of an Open Flame in a Room Where a Storage Battery Is Being Charged** or in which it has been left for some time, as an explosive mixture of air and hydrogen may be formed.

(10) **Prepared Electrolyte May Be Purchased** if desired.

(11) **Storage Batteries Are Rated in Ampere-Hours,** this being based on the steady current the battery will discharge for eight hours. A battery that will discharge at five amperes for eight hours without the voltage falling below 1.75 is rated as a 40-ampere-hour battery. This does not mean that 40 amperes would be the output of the battery if discharged in one hour. The ampere-hour capacity decreases with the increase in current output.

(12) **The Current in Charging** should be kept within the maker's specified limit. One authority advises for rapid charging covering a period of three hours, 50 per cent, 33 per cent and 16 2-3 per cent of the total current for each consecutive hour.

(13) **The E. M. F. of the Charging Current at Starting** the charge should be about five per cent higher than the normanl e. m. f. of the battery. After a few minutes this voltage may be 10 or 15 per cent of the normal battery e. m. f. However, the battery is kept in the best condition by using a constant charging current and if necessary to maintain this the voltage may be raised to 40 per cent of the normal battery voltage.

(14 **Be Sure the Positive Pole of the Charging Mains Is Connected to the Positive Side** of the battery.

(15) **To Determine the Polarity** hold the two wires in a glass of acidulated water or electrolyte, keeping them at least ½ inch apart. Gas will collect most at the negative lead.

(16) **A Cell Is Fully Charged:** (a) If,with a constant current, the voltage and specific gravity do not change for 25 or 30 minutes. (b) When the plates decidedly increase the quantity of gas given off. (c) When the specific gravity measures 1.2, and the voltage from 2.5 to 2.7. (d) When the negative plate assumes a light gray color and the positive plate turns a dark brown.

(17) **Never Adopt the Method of Putting a Wire Across the Positive and Negative Terminals to See If There Is Any "Spark."** It is almost a dead short circuit, and if the cell be of a small capacity of say thirty ampere hour, and the wire No. 16 copper, the current may be anything from thirty to one nundred amperes for a fraction of time, which when calculated is a very appreciable amount of the total capacity, if only for a second of time duration. It is also very detrimental to the cell in assisting the disintegration of the plates or active material thereon.

(18) **Lead Cells** should not be discharged below 1.7 volts.

(19) **Boiling Does No Harm,** unless the paste is loose, when the agitation will remove it.

(20) **If the Cells Are Hot While Charging** reduce the charging current.

(21) **If a Battery Is Not in Use** give it a short charge once a week.

(22) **If White Sulphate Is Formed on the Grids** it may be reduced by charging at a high rate or overcharging at a low rate for two or three hours.

(23) **Continued Sulphating Will Buckle the Plates,** as will also too rapid discharging.

(24) **A Cell That Has Been Short Circuited Should Be Disconnected** from the battery and charged and discharged several times separately.

(25) **Makers Furnish Directions for Keeping Batteries When Not in Use. One Way to do This** is to charge the battery fully, then siphon the electrolyte (liquid in jar) out of the jars, to be kept until used again. Then fill the cell at the normal rate until the cell shows less than one volt. The plates may then be removed and stored.

(26) **Never Allow the Cells to Stand in a discharged Condition,** as it becomes very difficult to get them properly charged if left standing any length of time unless great care is taken during the succeeding charge.

(27) **Do Not Forget That the Discharge Current** is capable of adjustment by the vibrator of the sparking coil.

The Current Rate of the Discharge Should Be About One-Half an Ampere, but a badly adjusted coil may take as much as three or even more amperes, thus eating up the energy of the cells, in ampere hours, in one-sixth of the time.

Thus a Thirty Ampere Hour Cell Discharging at One-Half an Ampere Per Hour will last sixty hours, but discharging at three amperes will only last eight or nine hours.

(28) **If the Terminals Begin to Corrode,** use vaseline.

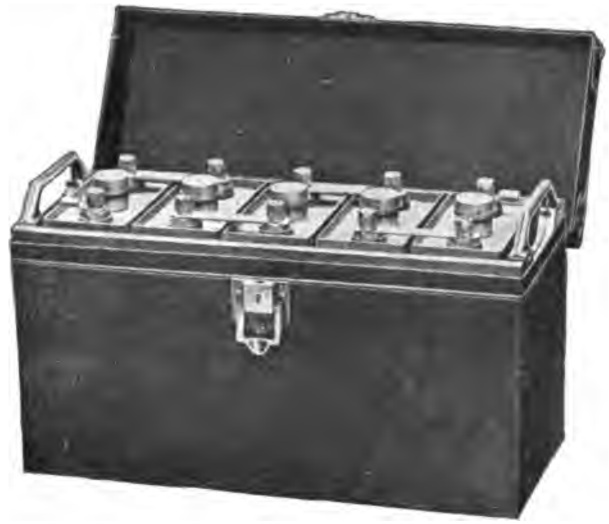


Fig. 1—The Edison Ignition Storage Battery

Contained in a metal box. There are five cells, each cell delivers about 1.2 volts each. Note the voltage or pressure of each cell is low, therefore more cells are required to give the usual 6 volt pressure.

Other cells give two volts, therefore only three cells are necessary.

The advantage claimed by the makers is in the output or amperage of the battery. They claim that with five of their cells, weighing less than three cells, the amperage, or quantity of current the battery will deliver will be twice as much as the three cell battery.

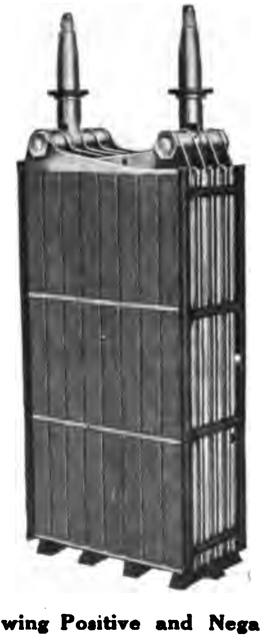


Fig. 2—Showing Positive and Negative Plates of the A-4 Cell Assembled together, but Removed from the Container

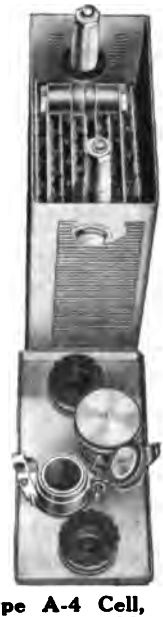


Fig. 3—Type A-4 Cell, Showing the Positive and Negative Plates in the Container, and also the Removed Cover with Openings

The retaining jar is made of sheet steel and electroplated with nickel.

THE NEW EDISON STORAGE BATTERY.

The Plates in the Edison battery are not made of lead neither is acid used for the solution.

The Plates are Made of Nickel and Iron, the former in the form of a hydrate and the latter as an oxide.

The Electrolyte is a solution of potassium hydrate (potash).

The Structural Parts, including the containers for the active material and their supporting grids, and the connections and outer cases are made of nickel-plated steel.

THE PLATES.

In This Form of Battery the Positive Plates Consist of Steel Grids, Which are Nickel-plated; they are in the form of nets of 30 tubes per grid, each of which is filled with active material, the latter being composed of pure metallic nickel in the form of leaves or flakes.

The Pure Nickel Flake is Produced by an electro-chemical process.

The Negative Plates are Composed of 24 flat rectangular pockets which are supported in three horizontal rows in nickel-plated steel grids.

These Pockets are Also Formed Out of Thin Nickel-plated Steel and they are full of perforations.

The Active Material in the pockets forming the negative element of the battery is oxide of iron.

The Positive and Negative Plates are Assembled Alternately, as shown in Fig. 2, where they are placed within the containing cell, which is also made of sheet steel.

THE ELECTRIC VEHICLE—BRIEF EXPLANATION

The Electric Vehicle may be considered made up of three parts; a body; the chassis, running the steering gear, and the power plant with controller. The last mentioned, consisting of a storage battery and a motor with a special switch, is a very simple proposition compared with the power plant of the gasoline vehicle, with its gasoline tank, carburetor, engine, ignition, radiator, change gears, lubrication system, etc.

The Recognized Place of the electric pleasure vehicle is distinctly that of a "town car," small and light compared with a gasoline touring car.

The Objections to the Electric Vehicle is the recharging of the storage batteries. An electric vehicle will travel just the number of miles its battery will permit and then it must be recharged.

An Electric Motor "M" Is Mounted to the Frame. Illustration Fig. 1 and 2, Chart 116A shows two methods of drive.

The Electric Batteries Are Made on the Same Principle as used for ignition, explained under "Storage Batteries" in this book.

The Batteries Are Mounted on the Frame or Chassis as shown in Fig. 1.

A Box Contains the Cells, a cell is one set of elements contained in a liquid solution in a hard rubber jar.

Each Cell Gives Two Volts of pressure—if the motor requires 80 volts pressure to run it at full speed, then 40 cells of batteries must be on hand to supply full speed.

By Observing the 2 Boxes of Batteries "B" in Fig. 1 the reader will note that these cells are connected together by lead plates.

The Speed of the Vehicle Depends on the Voltage; if full speed all cells (40) are connected in series. If second speed or medium then only part are connected thereby reducing the voltage . On low speed only a very few cells are used connected in series and the voltage drops, consequently the speed of the motor.

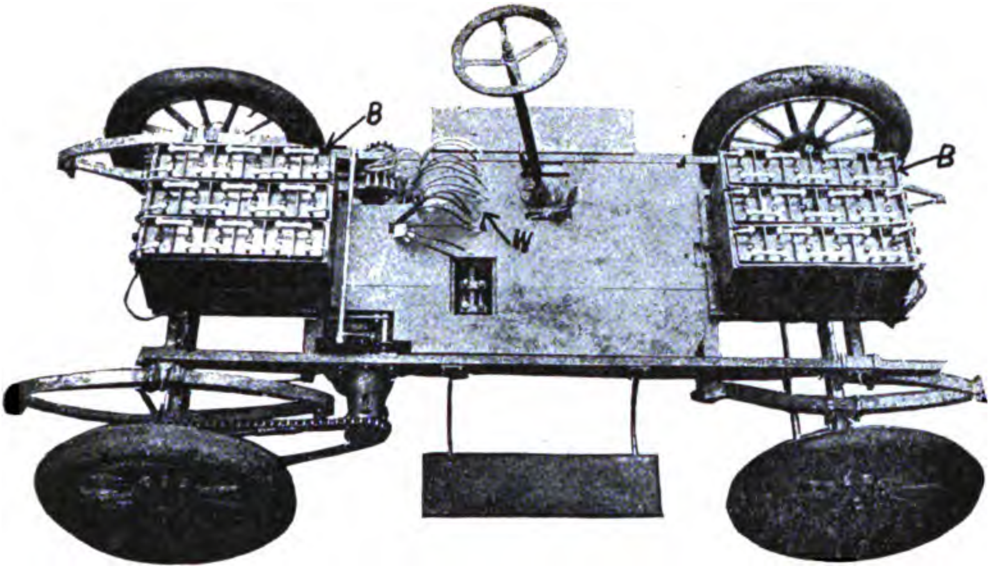


Fig. 1—Chain Driven Electric Vehicle with Body detached, showing the Battery System

B—Storage batteries. W—Wires to controller.

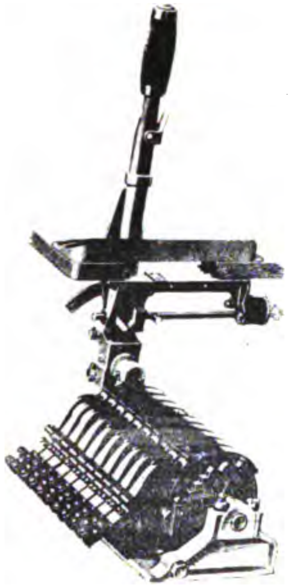


Fig. 3
An Electric Controller

A system of switches placed usually underneath the seat of a car with the handle protruding to the side of the seat.

The purpose of the controller is to start, stop and regulate the speed of an electric vehicle by throwing in connection different groups of cells.

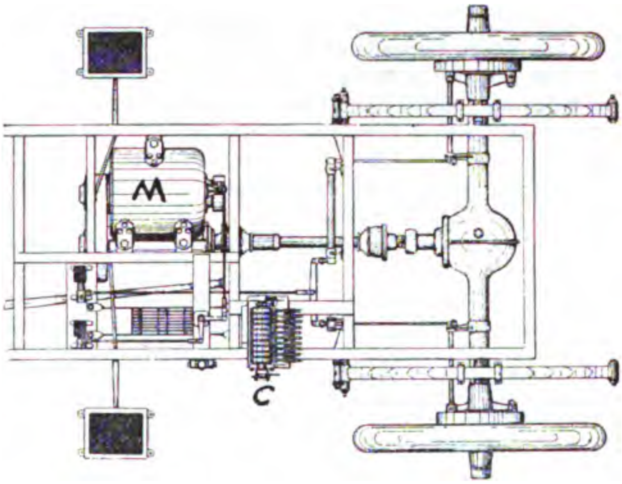


Fig. 2
An Electric Vehicle with a Propeller or Shaft Drive.

M—Electric motor.

C—Controller.

The Electric Vehicle
CHART No. 116A

A Controller, Fig. 2, "C" is used to regulate or connect and disconnect these batteries in order to give the speeds. (See illustration, Fig. 3 also note wires "W" to controller in Fig. 1.)

The Controller in an Electric Vehicle performs practically the same function as the change speed mechanism in a gasoline car. It controls the flow of current to the motor, and so regulates the speed of the vehicle and the construction is similar to those used on street cars.

A Very Good Illustration of an up-to-date controller is seen in the engraving of the Fig. 3 controller, in which the contact fingers are resting in neutral position between the series of contacts, with the controller handle standing vertically 3 speeds and reverse are usual.

BATTERIES.

It Has Become Standard Practice to divide the battery, placing approximately half of the cells at the front end of the chassis, on a rack level with the frame, and covering them with a wooden hood extending out in front of the dash or forward end of the body proper. The rest of the cells are placed in a similar position at the rear, where they are covered with a wooden boot. The hood and boot are either hinged or removable. This disposition of the battry distributes the weight better on the frame, bringing it more directly over the axles and leaving the middle of the frame to support only the weight of the motor and transmission, body and passengers.

Various Makes of Batteries Are Used, the Exide lead battery of 26 to 42 cells, being specified as regular equipment in a majority of cases, with other makes optional. The Babcock, however, is provided with batteries made in the Babcock factory. The Bailey victoria and the Lansden vehicles are equipped exclusively with the new Edison nickle-iron battery, and one or two other makes are designed to take the Edison battery when ordered by the purchaser.

MILEAGE AND SPEED.

The Speed Depends on the Voltage or pressure.

The Number of Miles an Electric Vehicle Will Run Depends on the Size of the Cells or Amperage output (amperage means quantity) the larger the cell the more quantity of current it will deliver, but the pressure or voltage always remains the same, whether large or small.

If the Battery Gives 60 Amperes for 1 Hour, or one ampere for 60 hours then it is called a 60 ampere hour battery.

If the Motor on an Electric Vehicle Requires 10 Amperes Per Hour and your battery was a 60 ampere hour battery then you could run your motor steadily for 6 hours and if your speed was 15 miles per hour you could make 90 miles—providing that you were running on a perfectly level floor, but when you come to grades your motor will require more quantity of current or more amperage, possibly 30 amperes for a few minutes or when starting off on a grade the motor will pull considerable current from the battery. THEREFORE THE MILEAGE IS GOVERNED BY THE SIZE OF THE CELLS AND THE GRADES and starting up and a great deal in the manner the driver uses his control.

It is Practically impossible to state in definite terms the possible mileage per battery charge. On test runs the Bailey, fitted with Edison battery, has run 150 miles on a single charge. When fitted with a 40-cell Edison battery weighing 540 pounds, the regular mileage to be expected is placed by the makers of the vehicle at 75 to 125 miles. Equipped with a 54-cell battery of the same make weighing 729 pounds, the mileage should be from 100 to 150 miles. When furnished equipped with the lead battery the car is sold to run from 40 to 50 miles on a charge. The speed range is up to a maximum of 20 miles per hour.

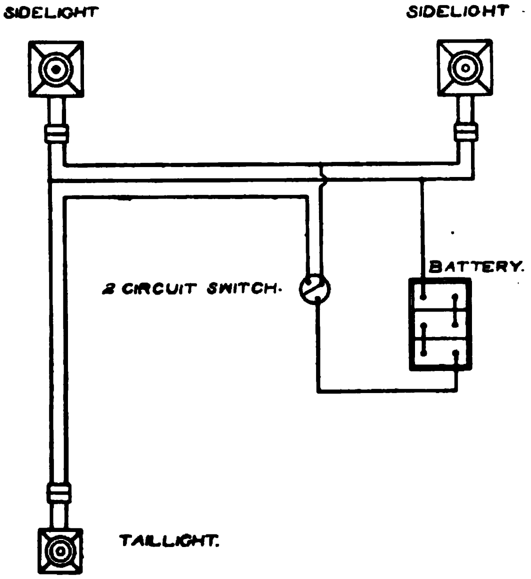


Fig. 1—Plan for Lighting a Car on One Two-Circuit Switch; to Light the Sides or Tail Light Separately or Together.

Material Necessary:

One special two-circuit push button switch.

20 feet rubber covered Duplex wire No. 12.

Six feet rubber covered Single wire No. 12.

One 6-volt Tungsten lamp for tail light.

Two 6-volt Tungsten lamps for side lights.

Fittings for side and tail lamps to take the electric sockets.

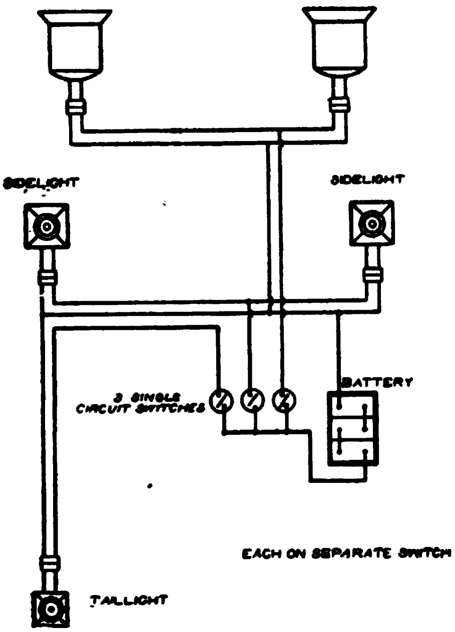


Fig. 2—Plan for Lighting the Head Lights Only

Material Necessary:

Fittings for two head lights.

12 feet rubber covered duplex wire, No. 12, stranded.

6 feet rubber covered single wire, No. 12, flexible.

Two 6-volt Tungsten lamps.

One single circuit push button switch.

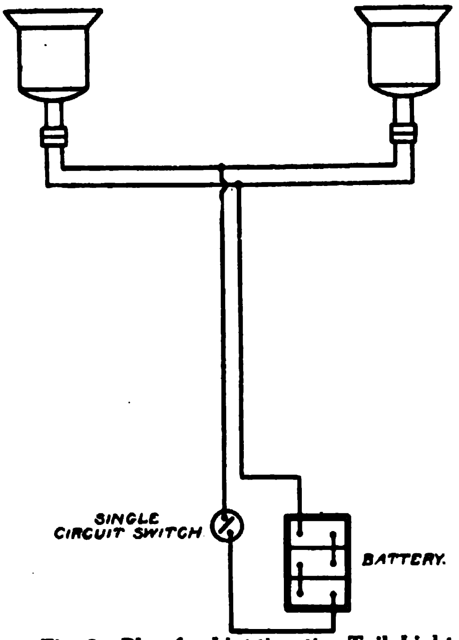


Fig. 3—Plan for Lighting the Tail Light, Head Light, and Side Lights, Each in a Separate Switch

Material Necessary:

Fittings for two side lights.
Fittings for two head lights.
Fittings for one tail light.
One 3-circuit push button switch.

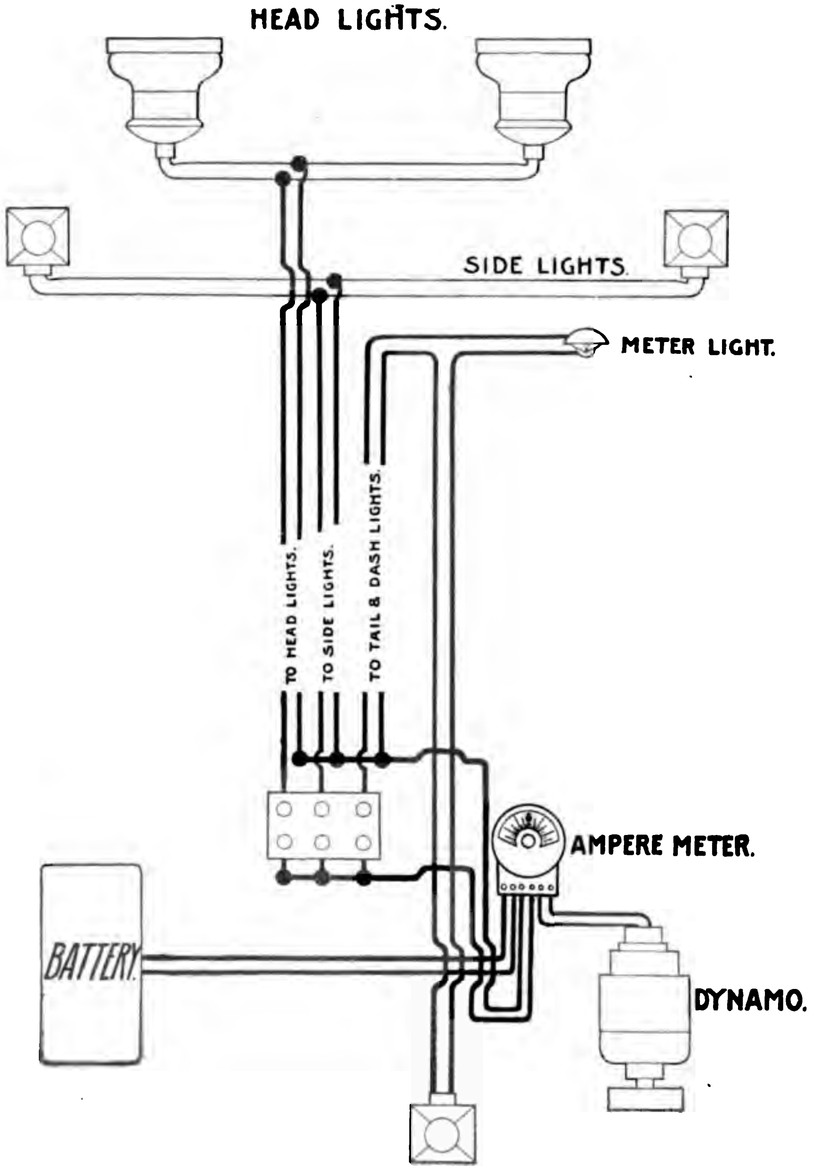
35 feet rubber covered duplex wire, No. 12 stranded.

10 feet rubber covered single wire, No. 12 flexible.

Six 6-volt Tungsten lamps.

Diagrams of Wiring for Lighting Cars with Electric Lights, Using a Storage Battery

CHART No. 117



The Automatic Electric Lighting System for Cars

The system above is similar to the systems used for car lighting on the great railways of this country and Europe, practically the only difference being that the automobile has few lights and therefore the units constituting the system are smaller, lower in voltage and less amperes are required.

The Elba Electric Dynamo System, herein described, consists of a Dynamo, Am-meter, Automatic Cutout, and a Storage Battery. **When the engine is running** the dynamo supplies current until the battery is fully charged, at which point the dynamo is automatically cut down until the battery falls below its maximum—when the generator again supplies sufficient current to bring up the battery charge again.

When the battery is full, and car is running, the dynamo supplies current direct to the lamps, and when car is at rest the lamps are operated from the battery. **This being an automatic system**, it will work from month to month with little or no attention, except the occasional addition of a little distilled water to the battery.

The same storage battery will also supply current for ignition.

The Dynamo is run by a belt, friction or other means from the engine.

CHART No. 118

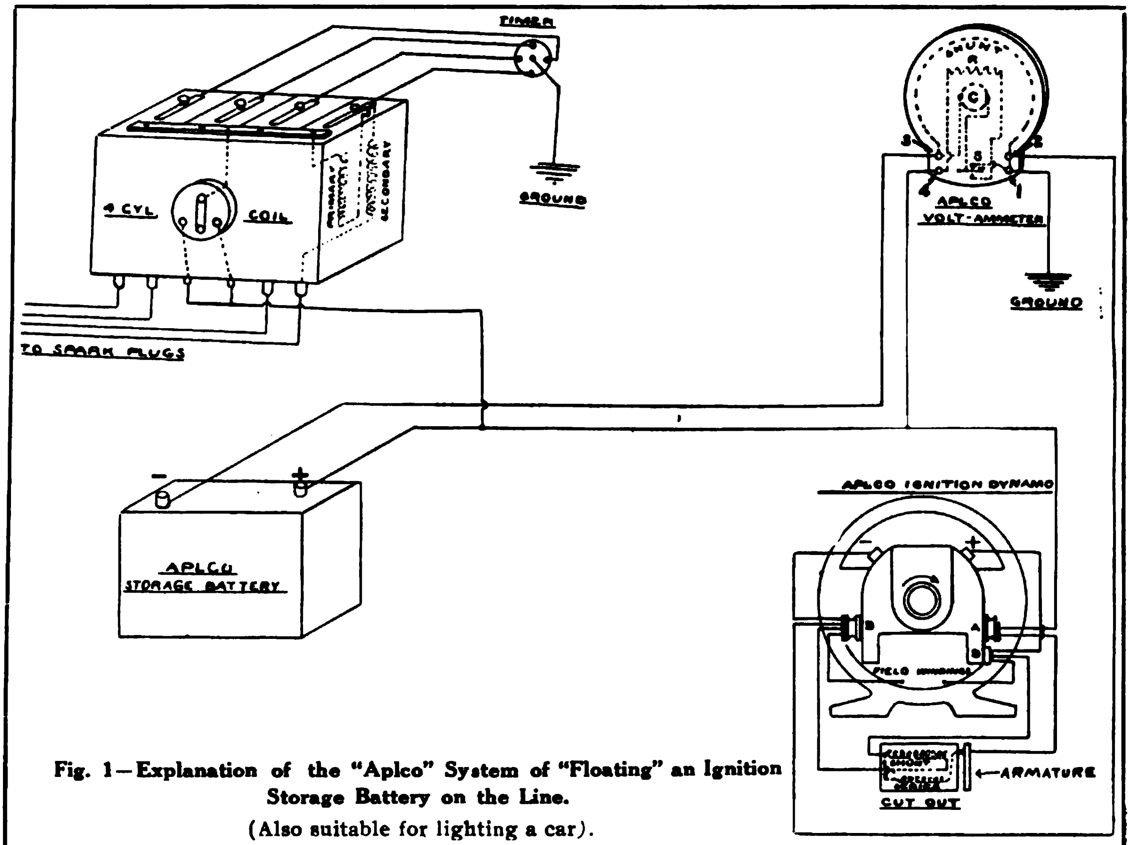


Fig. 1—Explanation of the "Aplco" System of "Floating" an Ignition Storage Battery on the Line.
(Also suitable for lighting a car).

This Dynamo is run from engine and is used to charge storage battery. This system is suitable for lighting a car and ignition also. The diagram, however, only shows the system wired for ignition.

The Dynamo is operated from the engine by belt or other means of drive. **The Dynamo Automatically Charges** the storage battery and the storage battery supplies current for ignition.

The "Cut-Out" is provided to automatically cut out the connection between the dynamo and storage battery when the engine stops or runs less than 6 miles per hour. Otherwise all the current put into the battery would go back into the dynamo.

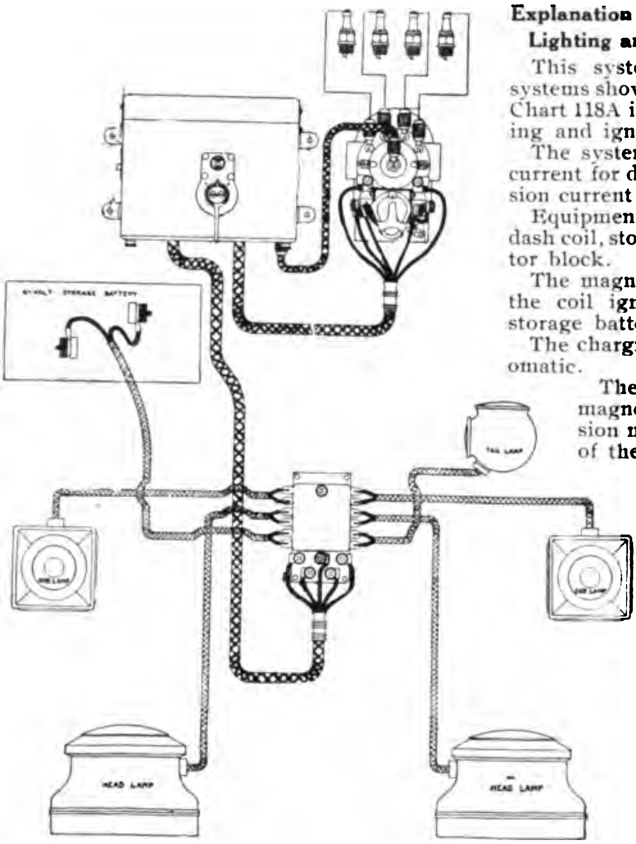
As the Dynamo Gets Up to Speed the current flows from the positive brush to the point D, then through the shunt winding of the cut-out to point B, and then to the negative brush of the machine. **The Current Flowing Through the Shunt Coil of the Cut-Out** draws in the cut-out armature and closes the cut-out switch. The path is then established through point D through the series winding of the cut-out, to point A and from A to the positive side of the battery.

From the Negative Side of the battery current flows in to point 3 of the volt-ammeter through the shunt of the instrument point 2, and back into the negative side of the dynamo. **The Current for the Coil** of the volt ammeter when it acts as an ammeter starts at point 3, passes through the coil, then through the upper contact of the switch S and into point 1, then to point 2.

When the Switch S is Pressed Down the instrument acts as a volt-meter, current flowing from point 3 through the coil C, through the switch S, through the resistance arrow to point 4. **Points 3 and 4 are Connected Across the Terminals of the Battery,** consequently the instrument shows the battery voltage.

The Drawing shows both contact points of the coil switch connected to the positive side of the storage battery. **Where it is Desired to Use Dry Cells** in addition to the storage battery one side of the switch may be disconnected from the storage battery and connected to the positive side of the dry cells, the negative side of the dry cells being grounded. **From the Positive Side of the Storage Battery** current flows through the switch to the bus bar on top of the coil box, through the primary winding of the coil, through the contact point, through the vibrator to the timer and into the ground. **From the Ground Into Point 1 of the Meter,** then through the meter to the negative side of the battery.

CHART No. 118A



Explanation of the Remy Combined Lighting and Dual Ignition System

This system is similar to the two systems shown in Chart No. 118 and Chart 118A if combined for both lighting and ignition.

The system provides high-tension current for dual ignition and low tension current for lighting.

Equipment consists of magneto, dash coil, storage battery and distributor block.

The magneto supplies current for the coil ignition and also keeps the storage battery charged.

The charging of the battery is automatic.

The difference between this magneto and a regular low tension magneto is in the winding of the armature.

The armature on this particular magneto (not regular Remy magneto) is drumwound, that is it is wound to deliver a "DIRECT" flow of electric current, whereas the regular magneto delivers an "alternating" current.

In fact this magneto would be called a dynamo if it had electro magnets instead of permanent field magnets.

The magneto supplies a direct current to coil and the coil increases the pressure of current which is distributed to the spark plugs by distributor on the magneto.

The magneto also charges the storage battery, which is "floated on the line." The instant the magneto output is not sufficient to carry the load, the storage battery supplies the required current by being automatically thrown into service.

The Regulator Inside the Coil Box holds the current at eight amperes.

Should the Magneto be Throttled Down to a point below speed sufficient to generate eight amperes, the storage battery is automatically thrown into service and supplies the required current.

With this System there is a Seventy-Degree Timing Range. Since there is a constant direct current, the spark is of the same intensity at any point in the timing range. The timing of the spark is accomplished by shifting the circuit breaker around the armature shaft to which is attached the circuit breaker cam. The current is interrupted by the circuit breaker and is then carried to the transformer coil unit inside of the coil box.

It is there Stepped Up or Transformed to the High Voltage necessary at the spark plugs for ignition. The high-tension impulses are carried back from the coil to the high-tension distributor on the magneto and thence properly distributed to the spark plugs. The magneto is so designed that it may be driven in either direction, that is, clock-wise or anti-clock-wise, without any changes.

The Ignition Kick Switch on the Coil Box has Three Positions, namely: Starting, Off, and Running. When the switch is thrown into "starting" the coil is operated by storage battery. This makes it possible to sometimes start on compression if there is a charge of gas in the cylinder.

Starting Without Cranking can be effected as long as the cylinder holds the fuel charge. If cranking is necessary, the motor starts much easier with the vibrating spark. When the motor is started, the ignition switch is thrown immediately to "running" position. The action of throwing the switch over to running position, disconnects the vibrator.

Upon the Side of the Dash Coil Box are the Switches of the Three Lamp Circuits, marked;—head, side and tail, thus allowing for lighting of all lamps, head lamps alone, the side and tail lamps, or any combination the driver desires.

A Five-Way Cable Leads From the Dash Coil Box to the Magneto and another five-way cable to the distribution board. The wires composing these cables are fitted with clips. The wires are different colors and the terminals on the distribution block and magneto are plainly marked so that the proper connections are quickly and easily made.

CHART No. 119.

INSTRUCTION No. 24

LIGHTING A CAR:—Electric Lighting. Gas Lighting. Generators. Gas Tanks.

ELECTRIC LIGHTING ON CARS.

It Is Possible Now, owing to the introduction of high-efficiency electric lamps giving very good illumination from a storage battery current, to adapt electric lighting very successfully to any car, both for interior lighting, in the case of limousines and landlaudets, and side and rear lamps.

It Is Well Worth Knowing That Any Oil Lamp Can Be Quickly and Inexpensively Converted to Electric by obtaining an "adaptor" from any of the large accessory dealers.

This Is a Small Fitting which clamps on the burner or screws into the oil well and takes the place of the burner (the latter can then be kept stored away on the car as a reserve.)

The Lamps Used are small 6-volt high efficiency metallic filament bulbs, giving (nominally) 8-candle power for side lights, 4-candle power for tail lights and 16 to 24 for headlights and 8 c. p. for dome lights and consuming from .5 to 1 ampere of current.

These Lamps Are Appreciably More Delicate than the carbon filament lamp, the filament is more readily broken by shock; but if a point be made of buying a good cluster loop TUNGSTEN lamp, it will be found that there is but very small risk of fracture.

There Are Also Special Non-Vibrating Lamp Holders sold, which greatly minimize risk of breakage. Several spare bulbs, however, should always be carried.

The Wiring From Storage Battery to lamp should be of good substantial gauge.

The Most Satisfactory Kind is low-tension flexible, which ensures the light being efficient; as there will be practically no loss of volts along the wire, there will be no risk of short circuits, and it makes a permanent job.

LIGHTING WITH A STORAGE BATTERY AND DYNAMO TO CHARGE THE BATTERY.

A Good Example of a Standard Car-Lighting System with a self-regulating dynamo driven from the engine is that adopted by Willard Co., called "Elba" system, per chart 118, and the Apple Elect. Co.'s "Aplco" system, the principle of which has been tested with success.

The Merits of This System, are its extreme simplicity, completely automatic action and reliability under unfavorable conditions of working.

The Whole Plant Consists of a self-regulating dynamo of small size, which may be driven by gear or belt.

There Is an Auxiliary Device, consisting of a charging ammeter and automatic cut-in and cut-out may be fitted on the dash board if desired.

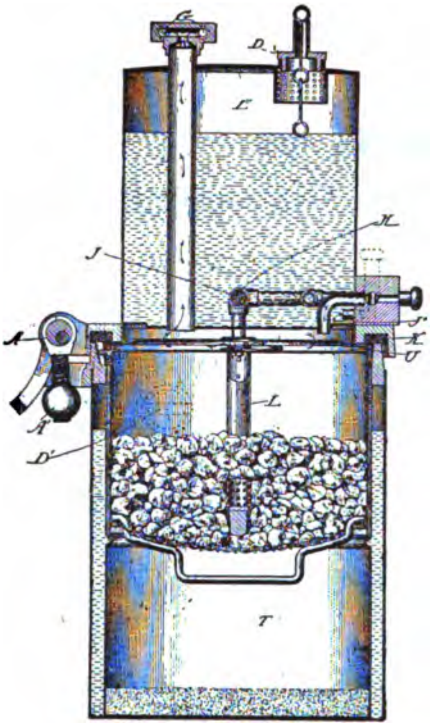


Fig. 1—Drip Type of Generator

The used up carbide shakes through the perforations into the base of the generator. The water tank forms the top part of the generator.

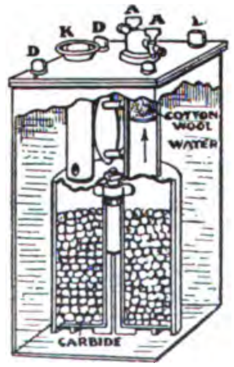


Fig. 2—Simple Form of Diving Bell Generator for Acetylene Gas

When the supply to lamps is shut off, the pressure of gas in the inner chamber drives the water away from the calcium carbide.

Explanation of the Drip Type of Carbide Generator

The tank (E) being filled at (D) the water saturates the wick (H) in the tube (J) and the valve (F) being turned ON it drops into the screen tube (L) passing out of the holes at the bottom, coming in contact with the carbide in cage (C) and forms gas which passes out at top of generator. The unused carbide held in the cage is separated by the screen in the bottom and the dust or used carbide falls to the bottom perfectly dry. Consequently the charge is always fresh while it lasts and ready to light or extinguish, and cleaning simply means emptying the dry dust at the bottom and refilling the cage with carbide and the tank with water. To shut off the light turn the valve (F) off; (F) being a two way valve, the gas then contained in the generator passes out of the two-way valve into the air, thus **insuring perfect safety.**

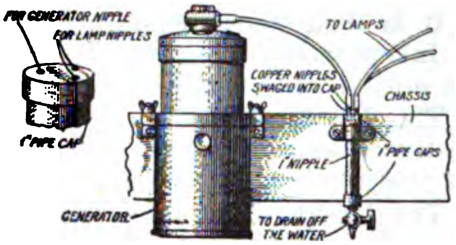


Fig. 4—How to Connect to Avoid Condensation

Water in the gas line is a common trouble and is caused from the gas condensing and there is no way for the water to get out of the pipes unless some arrangement is made like in the illustration.

Take a 1 inch pipe cap and drill three holes for ⅛ inch copper nipples 1⅛ inches long. so they will be a tight fit. Drive them in so they project ⅛ inch below the inside of the cap, then swage them with a punch, so they will remain tight. The rubber tubes from generator to lamps fit over them. Take another cap and tap for ⅛ inch pet cock. Screw them on to a 1 inch nipple 4 inches long, and clamp to the chassis as shown, so that the top will be at the lowest point in the gas system. Connect up as shown, and all water in the pipes will drain to the separator from which it can be drained by the pet cock. The separator also acts as a gas reservoir to equalize the pressure on the burners.

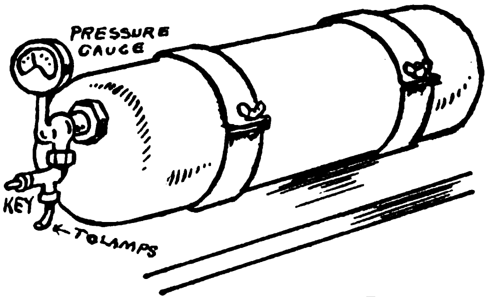


Fig. 3—Gas Tank Placed on the Running Board, or Elsewhere, on a Car

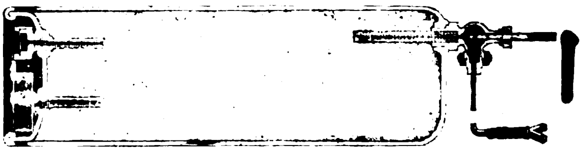


Fig. 4 - Sectional View of the Gas Tank

CHART No. 120.

The Dynamo gives 6 volts and 6 amperes at a very moderate speed. The armature which is of the slotted drum type, as shown, runs on ball bearings, and the machine is quite dust proof.

It Is Quite Free of Working Parts, there being merely the ordinary armature and carbon brushes, which are self-adjusting.

A Cut-in and Cut-Out System, and safety fuses are provided.

The Special Principle Adopted in the dynamo gives it an electrical efficiency which, for the size of the machine, is very high, none of the output being wasted in obtaining regulation.

The Mountain of the Dynamo on the Car may be effected in a number of ways.

For Example, it can be installed on a standard four-cylinder car in the space between engine and forward end of the frame, just behind the radiator, the drive being by gear wheels from the half-speed shaft.

Provision Is Made on the dynamo for mounting an intermediate pinion if required.

The Wires Should Preferably be carried in steel tubing, giving protection from wet and injury.

The Dynamo Is Arranged so that it never runs on open circuit when not required to supply lighting current.

A Two-Way Charging Switch, when in the "off" position, automatically inserts a resistance in the dynamo field coils, which reduces the output to a very small amount.

This Current Goes into the storage batteries, and thus always keeps it charged.

ACETYLENE GAS LIGHTING.

GAS GENERATOR.

The Independent Generator conveniently mounted alongside the chassis.

If Required, a steady supply of gas for two or more lamps can be obtained and controlled, and with the maximum economy of material.

There Are Several Principles on which the construction of acetylene generators may be based.

THE DRIP GENERATOR.

In the "Drip" Principle of generation the water is usually arranged to drip directly on to the carbide, and the amount of gas formed is regulated by a tap, which allows more or less water to come in contact with the carbide. (Fig. 1, Chart 120.)

A Modification of This System allows the water to drip down a perforated metal tube surrounded with carbide, and thus the water gradually soaks through the carbide.

All Generators are Now Made Specially with a view to ease of detachment, refilling or charging, and cleaning; this latter is specially important, as any neglect to clean out the lime residue which form, from the container, immediately after a period of use, renders cleaning a matter of considerable difficulty.

Another Important Detail in working a generator is always to obtain the best quality of carbide, keep it in a thoroughly dry place, and tightly sealed up to prevent deterioration.

When Charging the Carbide Container, allowance must be made for expansion of the carbide when it becomes exhausted, so that only the amount advised in the directions supplied with the generator should be put in.

THE DIVING BELL PRINCIPLE OF CONSTRUCTION OF GENERATOR.

In Some Respects It Is Simpler and gives a better regulation of the gas, but it does not seem to be always reliable.

In Brief, the Working Is as Follows:—the Carbide Is Contained in a Bell or Chamber with perforated sides and bottom to admit water freely. This bell has a suitable outlet for the gas. (Fig. 2, Chart 120.)

It Is Supported Inside an outer vessel or tank to hold the water.

Immediately the Water Comes in Contact with the carbide, gas is generated and, if the supply tap is open, this gas will pass on to the lamps.

Should the Tap Be Closed, the pressure exerted by the gas then acts inside the bell, and drives the water away from the carbide.

Should the Generation of Gas Still Continue for some time, it will force its way through the water and escape into the atmosphere through a small vent hole, so that no dangerous pressure can develop within the generator.

It Will Be Followed that an automatic regulation of the gas is thereby obtained, because immediately more is being generated than can be used, the water is driven away from the carbide, but as soon as there is a demand for more gas the pressure inside the bell falls and water re-enters. there is a continuation of equilibrium the whole time.

The Simple Generator illustrated in Chart 120, Fig. 2 shows how this principle is carried out.

There Is the "Bell" or Carbide Container with its gas outlet pipe and cotton wool or horsehair filter, whence the gas reaches the tape (A A).

It Will Be Noticed That There Is a Gas Bag arranged on the gas outlet pipe inside the generator to steady the pressure.

The Carbide Container lifts right out of the tank by unscrewing the nuts (D D).

The Tank Is Filled Up from the aperature (K), in the plug of which is a small vent acting as a safety valve.

In This, as in Other Forms, the gas can be turned on and off any number of times till the carbide is all used up.

CARBIDE.

The Chemical Formula for Acetylene is C H (i. e., a compound of carbon and hydrogen.)

It Has a Characteristic Pungent Odor—which at once gives evidence of any leakage—and is a poison if inhaled in any quantity.

Approximately 1 lb. of Good Quality Calcium Carbide Will Generate Six Cubic Feet of Acetylene Gas. It can readily be liquified or compressed, but in this state it is highly explosive, and its use finds no favor in this country.

What Is Known as Dissolved Acetylene, However, is perfectly safe.

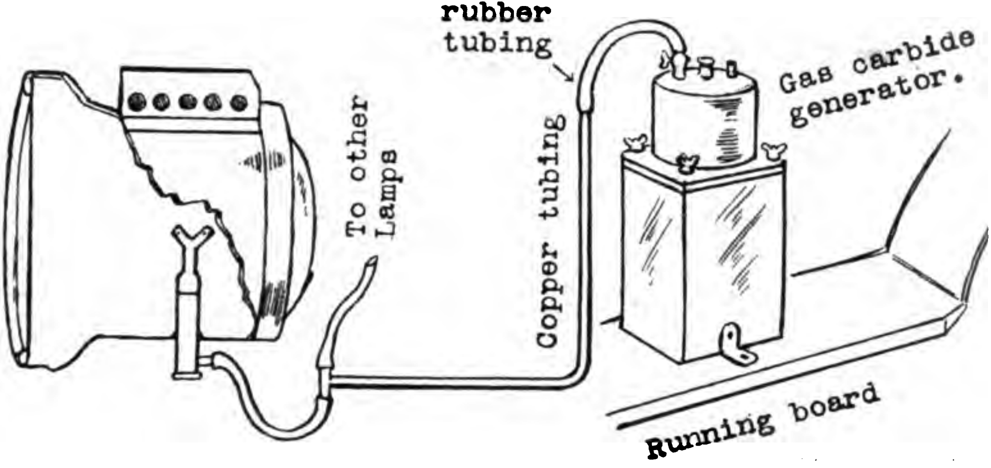


Fig. 1—Showing how Small 1-8 inch Copper Tubing and Rubber Tubing Connects from Generator to Lamps

Note the rubber tubing connected from the copper tubing to the lamp drops in a curve. This will place the rubber tubing at the lowest point. Gas condenses and turns to water and the water clogs the pipes and gas tips. If this rubber tubing is disconnected occasionally, the condensed water will drain out.

It is always necessary that the line or leads from the gas generator to the lamps be on as much of an incline as possible. The pipes to each lamp should be independent if possible.

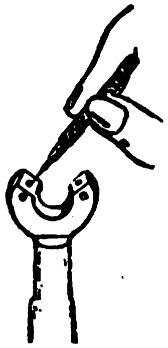


Fig. 2 — How to Clean a Gas Tip

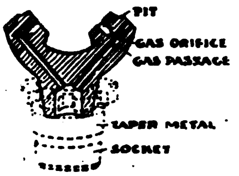


Fig 3—Interior of a Gas Tip or Acetylene Burner

Tips are generally made of lava. Two small holes are in each end, only one of these being discernible to the eye. The hole, however, which becomes clogged is the small hole inside the large one.

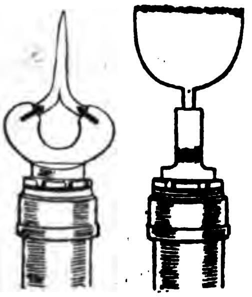
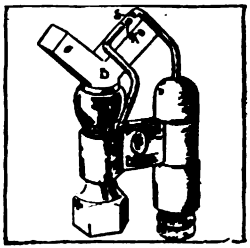
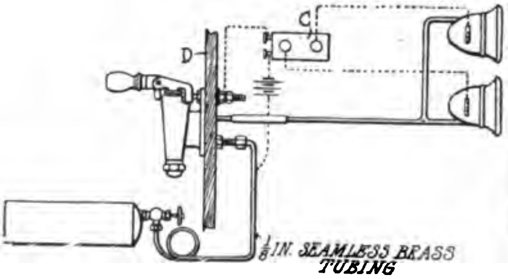


Fig. 4—Showing End and Side View of the Flame When Burner is in Good Order.



[illegible]



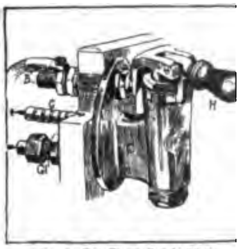


FIG. 6—THE FLASH GAS LIGHTER

FIG. 9—SHOWING COMPLETE OUTFIT CONNECTED UP

System for Turning on and Lighting the Gas Lights by Electricity from the Seat.

This System Consists of a special valve and switch, C and H, Fig. 6, a high tension coil C, and a special gas lighting attachment B1, Fig. 8,

The connections are as follows: The gas tank is piped to the valve C, by piping connecting to union G1. From G the gas pipe is carried to the lamps. From B the wire runs to coil, thence to battery.

Attachment B1 is placed on each gas tip to be lighted. When lever H is pressed down this opens the gas and also makes a temporary electric contact and spark jumps across points S, Fig. 8, and lights the gas flowing from hole K. The ignition battery will do this work.

CHART No. 121.

The Gas in a Moist or Impure State attacks copper or brass, forming acetylide of copper, which is exceedingly explosive, so much so that it will go off by slight friction or a blow.

This Accounts for the Small Explosions that are sometimes experienced when cleaning a generator or fittings.

In Cold Weather the water in a generator, if it be exposed to the air, is liable to freeze.

This Can Easily Be Guarded against by adding about one-third the volume of alcohol or spirits of wine to the water, or the generator can be protected by a felt-lined wood case.

GAS TANK.

Fig. 3, Chart 120, Illustrates a Gas Tank sometimes used instead of a gas generator.

It Is Made in 3 Styles; style E which weighs 23 lbs. Style B, 30 lbs. and style A, 50 lbs.

The Pressure Inside the tank E is based on a pressure of 15 atmospheres or about 50 cubic feet of gas which will supply gas for 2½ foot burners for 50 hours.

When This Tank Is Discharged then it is exchanged for a freshly charged one.

The Tank Should Be Placed on the car so that it can be easily removed. The running board is a convenient place.

NON-FREEZING SOLUTION FOR GAS GENERATORS.

It Sometimes Happens That the Water in Acetylene Generators and piping freezes.

Calcium Chloride in the Water Cannot Be Recommended, as in its usual form it contains acid, which has an action and chokes up the gas passages.

Denatured Alcohol Up to as High as 25 Per Cent. may be used without affecting the lights. There is very little loss from evaporation.

15 Per Cent. Alcohol and 10 Per Cent. Glycerine Have Been Used, but alcohol alone is to be preferred. If calcium chloride is used it must be pure. A solution of 20 parts to 80 parts of water freezes at 5 degrees F. above zero, but even less can be used as the interior of the generator does not get that low.

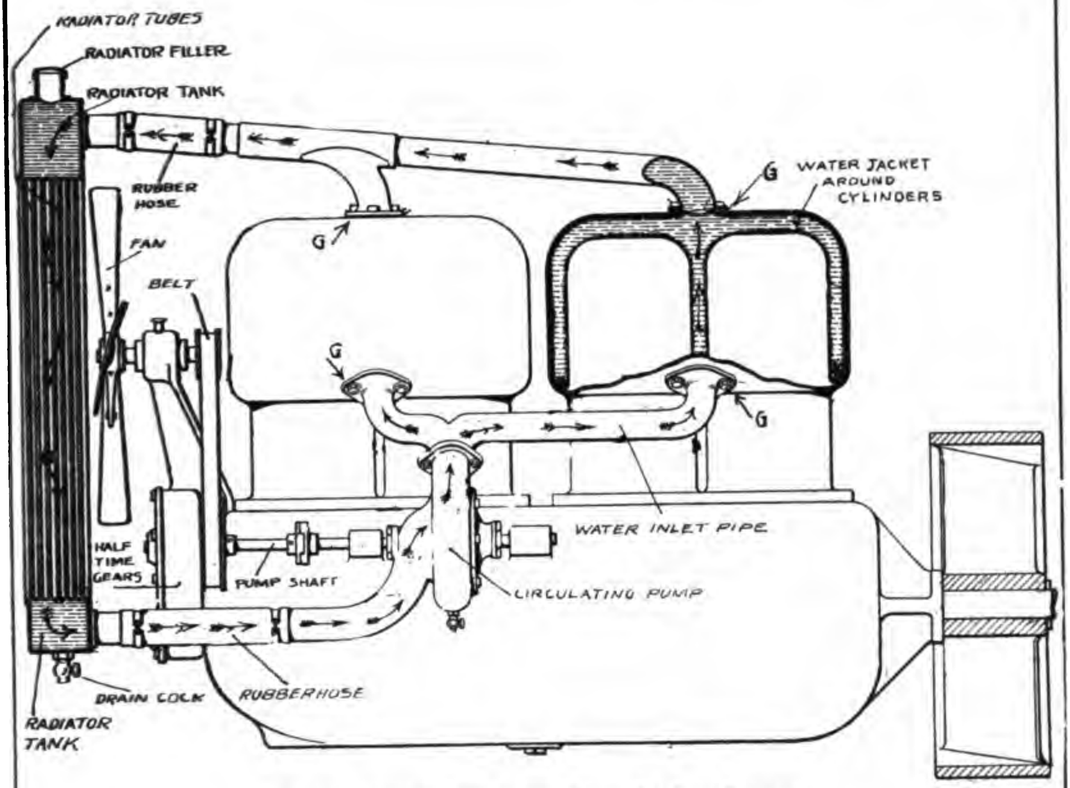


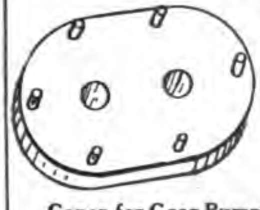
Fig. 1—Forced Circulation Water Cooling System

A pump is used in this system to force the circulation of water through the water jacket and radiator.

The fan is shown belted to pump shaft, **which is driven** by a gear from the cam shaft.

The fan draws air through the radiator tubes. Fresh air passing through the tubes tends to keep the water cool.

At the points "G" above, gaskets are used to make water tight joints with the water pipes.



Cover for Gear Pump

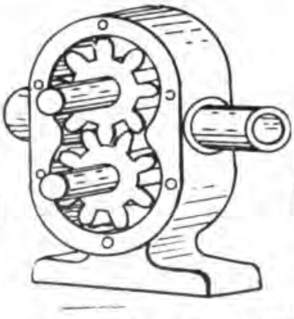


Fig. 2—Gear Pump

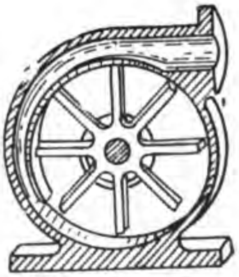


Fig. 3—Centrifugal Pump

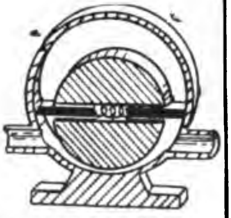


Fig. 4—Rotary Type

Force Circulating Pumps. There are three types of pumps, either of which may be used. **The pump is usually** driven by gears from a shaft from the half time gear.

The three types are illustrated above.

CHART No. 122

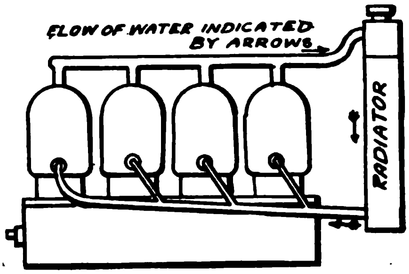


Fig. 1—Thermo-Syphon Circulation Water Cooling System

This system does not require a force pump to circulate the water.

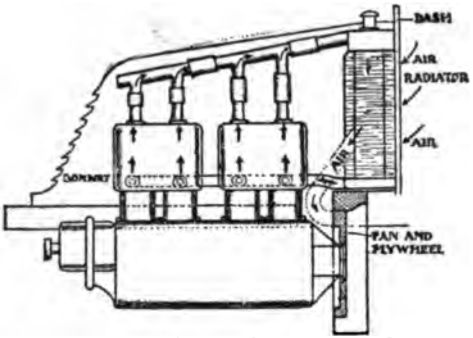


Fig. 3—Simple Thermo-Syphon Circulation. (Renault system) **Pump Dispensed with. The Arms of the Flywheel are Designed to Act as Fan-blades;** a separate fan is unnecessary, but the underpart of the engine must be carefully screened in.

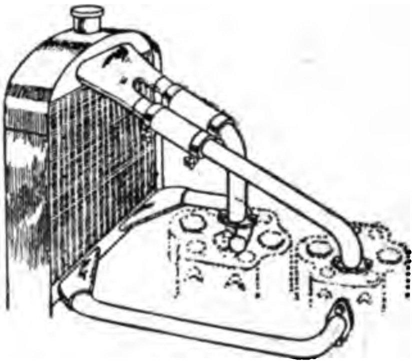


Fig. 2—A Thermo-Syphon System in Which Independent Pipes are Taken From Each Cylinder, the outlet pipes joining at the upper or tank part of the radiator.

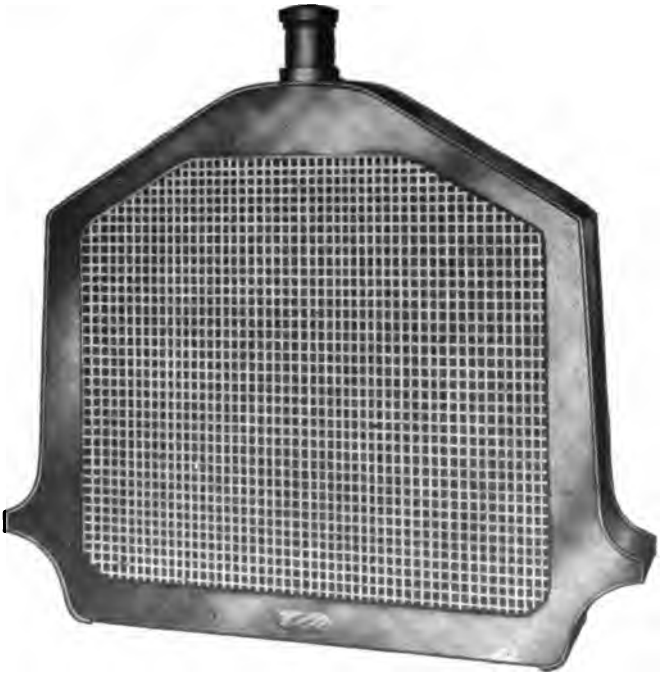


Fig. 4 — A Radiator

Usually placed in the front of a car. The water, after leaving the lower part of radiator, passes through the water jacket of engine, and is then forced through the radiator tubes. The water is cooled by air currents passing around the tubes, extracting the heat, in proportion to the available cooling surface exposed.

CHART No. 123

INSTRUCTION No. 25.

COOLING:—Water Cooling. Radiators. Force System of Circulation. Circulating Pumps. Thermo-Syphon System. Air Cooling. Fans. Care of the Cooling System. Cause of Trouble of the Circulating System. To Clean a Radiator. Stopping Leaks.

COOLING.

If No Provision Is Made for Cooling the Cylinder of a Gasoline Engine, the intense heat of the explosions would heat it to a point that would cause the lubricating oil to burn, and become useless.

At the Same Time, the cylinder must not be kept too cool, for that would prevent development of full power; the cylinder must therefore be permitted to get as hot as is possible without burning the lubricating oil.

The Cylinder May Be Cooled Either by Water or Air, and while the greater number of engines are water cooled, air cooling has been developed to a point where successful results are attained.

WATER COOLING SYSTEM.

The Water Cooling System Consists of jackets around the part of the cylinder that is to be cooled, through which water may flow; a radiator or cooler for cooling the heated water; and some method of keeping the water in circulation together with the necessary connections. (See Fig. 1, Chart 122.)

The Jackets are Usually Cast in One Piece with the cylinder although in some cases they are made by forming sheet copper around the cylinder to form passages through which the water may circulate.

When Heated, the water passes to the radiator, where the rush of air to which it is exposed absorbs the heat, cooling the water.

To Maintain the Cylinders at a Workable Temperature, a quantity of water is carried in a supply tank or radiator, from which it is caused to circulate continuously through the jacket of the motor cylinder by a small rotary pump driven direct from one of the camshafts.

The Heated Water From the Cylinder Returns Back to the Tank on Radiator and then passes through a series of thin copper tubes, which have radiating webs or flanges of thin metal surrounding them.

The Object of the Flanges is to dissipate as much as possible of the heat absorbed by the water by exposing it to a large cooling surface of metal.

The Radiator System Is Always Fixed in the Forward Part of the Car, to obtain the full benefit of the draught of air.

The Same Water Is Used Over and Over again, so that it is only necessary to replace the loss caused by evaporation.

It Is Usual on Radiator Systems to Have a Rotary Fan to assist in inducing a draught of cold air through the radiators and accelerating the cooling when the car is moving slowly, as in hill-climbing or slow running in traffic.

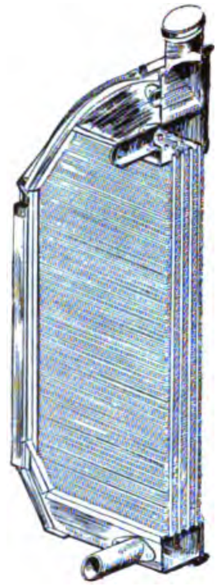


Fig 1—Tubular Type of Radiator

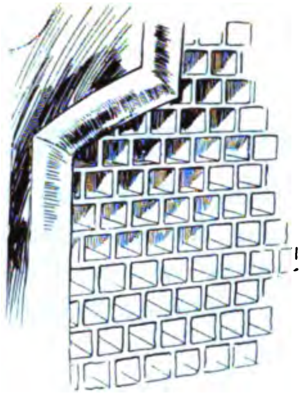


Fig. 2 — Cellular Type of Raidator

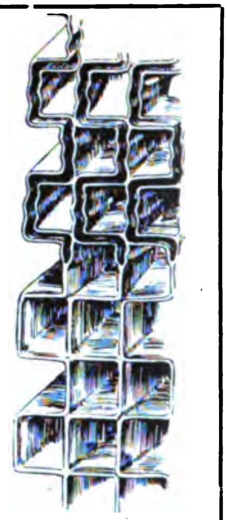


Fig. 3-Honeycomb Type. This is really a tubular type. Tubes are zig-zag shape, giving the honeycomb effect.

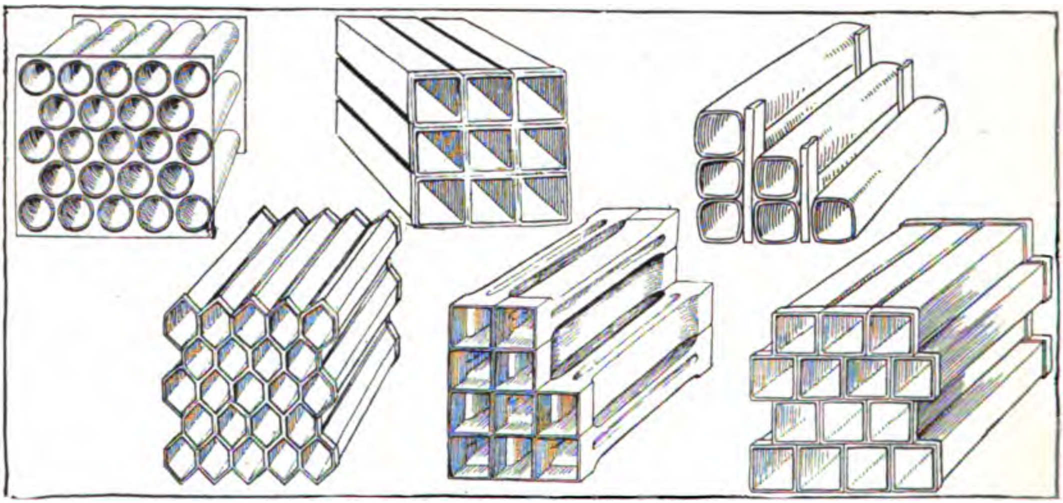


Fig. 4 Cellular Type of Radiator Tubes

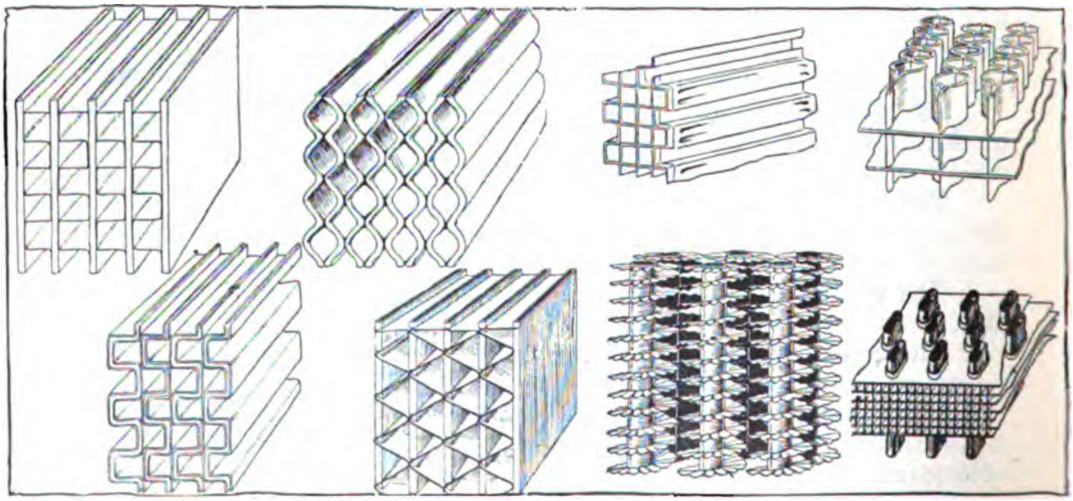


Fig. 5 – Tubular Type of Radiator Tubes

CHART No. 124

The Fan Is Driven From the Motor Shaft by a belt or gear and fixed at the back of the radiator. (See Fig. 1, Chart 122.)

An Alternative Method, Which Avoids the Use of a Separate Fan, is provided by fan-vaned arms in the flywheel. (See Fig. 3, Chart 123.)

RADIATORS.

There are Numerous modifications and types of radiators.

Radiators are Usually Divided Into Two Types, the CELLULAR or HONEYCOMB and the TUBULAR. (See Fig. 1, 2 and 3, Chart 124.)

There Is a Third Type in which the water circulation is like that in the tubular radiator, but whose general appearance is much like that of the cellular radiator.

This Is the Radiator in Which Zig Zag Pipes are Arranged vertically as shown in Fig. 3, and should be classed as a tubular radiator, although it is often called honeycomb.

THE TUBULAR TYPE.

A Tubular Radiator is one comprised of a series of tubular water passages.

These Tubular Passages may be arranged horizontally, vertically, or at an angle; or bent in a zig-zig fashion that brings about a combination of the horizontal and vertical, or oppositely disposed angular flow of water through the tubes; the object of the latter generally being to imitate or bring about the appearance of the cellular construction.

Several Tubular Radiator Constructions are shown in Fig. 5,Chart 124. It will be noticed that many of these have the true honeycomb appearance.

CELLULAR TYPE.

A Cellular Radiator is one comprised of a large number of individual air cells, anyone of which may be removed and replaced by another in case of leakage.

In a Cellular Radiator the air cells may be entirely surrounded by water when the radiator is in operation and the course of the water circulation through the radiator is not confined to any definite horizontal, vertical or angular course. Several types of cellular radiator construction as shown in Fig. 4, Chart 124.

HONEYCOMB TYPE.

A Honeycomb Radiator is a term applied to a cellular type of radiator, therefore one has the option of calling a cellular type of radiator a honeycomb type.

In Order to Grasp the Difference between a cellular and tubular construction, it must be borne in mind that in the radiator the hot water enters at the top, passes downward through it and out at the bottom to the waterjackets, becoming cooler in its progress.

In a Tubular Radiator, if vertical tubes are used, the water can pass downward through all of the forty or more tubes.

If One Tube Becomes Clogged Up, all of the water must go through the other thirty-nine.

Each Tube Is a Separate Path through the radiator.

In the Cellular Radiator the water passages constitute a system of spaces or cells much like the cellular construction of plants or the wax comb in which honey is stored.

Usually Cellular Radiators Are Formed in Three or Four Divisions, as indicated by the horizontal lines across the radiator.

Where These Lines Cross the Radiator there are open horizontal passages through which the water may flow from one side to the other.

In Each Division there is a series of zig-zag water spaces.

In Some Types these spaces are really zig-zag tubes, but in others they offer not only and up and down path for the water, but also interconnect to give a horizontal flow as well.

Tubular Radiators May Be Built Up of Tubes placed either vertically or horizontlally, and which run through fins, as shown in Fig. 5 Chart 124, to assist in radiating the heat. The true cellular or honeycomb type of radiator is not only more efficient, but is more expensive to construct and is found more generally on the higher-priced cars.

THE FORCE SYSTEM OF CIRCULATION.

In Force System, the engine drives a pump that keeps the water in constant circulation, and the pump may be any one of three types shown on Chart 122. A plunger pump is never used.

The Pump Forces the Water From Bottom of Radiator to the Inlet at the Bottom of the Water Jacket, through which it flows to the outlet at the top, whence it goes to the top of the radiator, flows through the radiator to the bottom. After passing through in this manner it is again drawn through the pump. (See Chart 122.)

CIRCULATING PUMPS.

Practically All Pumps are Driven by a Gear on the Crank Shaft or cam shaft, so that the motion is positive, and without slipping.

There are Three Types of Circulating Pumps in general use, the GEAR TYPE, the CENTRIFUGAL TYPE and the ROTARY TYPE. (See Chart 124, Fig. 2, 3 and 4.)

The Gear Pump consists of two small gears with large teeth, the two being in mesh, and placed in a casing that fits as snugly as possible.

The water enters at one side, where the teeth come together, and is carried around to the opposite side in the spaces between the teeth, where it escapes through an outlet.

The Centrifugal Pump acts on the principle of an air blower, and has blades projecting from a hub, which revolves at high speed inside of a casing.

The water enters at the hub, and is thrown outward by the blades to outlet in casing.

The Rotary Pump consists of a ring-shaped casing, within which a disc revolves, the disc being ECCENTRIC, or to one side of the center of the casing.

Through a slot across the disc are two arms, their ends being pressed against the casing by a spring.

As the disc revolves, the water is pushed from the inlet to the outlet by the arms.

THE THERMO-SYPHON SYSTEM OF WATER CIRCULATION.

The Thermo-Syphon System operates because when water is heated, it rises. (Chart 123.)

The Connections Are the Same as for the Force System, except that there is no pump, and the connection from the water jacket outlet to the top of the radiator slants upward.

The Passages Must All Be as Free and Clear as Possible, in order that there may be no obstructions to the flow of the water.

When the Engine Is Started, the water in the jackets becomes heated, and rises, flowing out of the jackets and through the slanting pipe to the radiator, its place being taken by the cool water from the bottom of the radiator.

The Circulation Is Continuous as long as the engine runs, and the passages are clear.

It Is More Necessary to Have Clear Passages for the Thermo-Syphon System Than for the Force System, because the pump will force the water past an obstruction that would stop the flow of water that moves only because of its heat.

Radiators are Usually Made Large Enough to Hold the Entire Supply of Water, but in some cases an extra tank is used, in which event the water flows from the jacket to the radiator, then to the tank, and from there to the pump.

FANS.

In Order to Cool the Water Sufficiently, a fan, driven by a belt from the engine, is often attached to the radiator, so that it draws a current of air through the passages in addition to the air current caused by the motion of the car.

The Fan is held in bearings supported on braces extending from the sides of the radiator, and is driven by a belt of leather, cord, or coiled wire from a pulley on the end of the crank shaft, or it may be attached to a special bracket on engine as shown in Fig. 1, Chart 122.

AIR COOLING.

As the Object of Cooling Is to Remove the Excess Heat From the Cylinder, a number of cars are on the market in which this is accomplished by the air direct without the use of water.

It Is Necessary to Give the Cylinder a Large Surface on Which the Air May Act, and the most usual method is to make it with deep flanges projecting from the walls and head, as well as the valve chambers, which become heated, as they are part of the cylinder.

A Strong Current of Air Blown Against the Flanges by a Fan Cools Them, keeping the cylinder cool.

This Flange Method Is Used on the Aerocar, Franklin, Marion, Waltham, Premier, and other cars. (See Fig. 1, Chart 125.)

The System Used by the Knox and Corbin cars is to have a great number of pins or studs projecting from the cylinder, and these either have screw threads cut on their surfaces to increase the space on which the air acts, or are U-shaped copper strips, with saw-tooth edges. Sometimes called the "Porcupine" system.

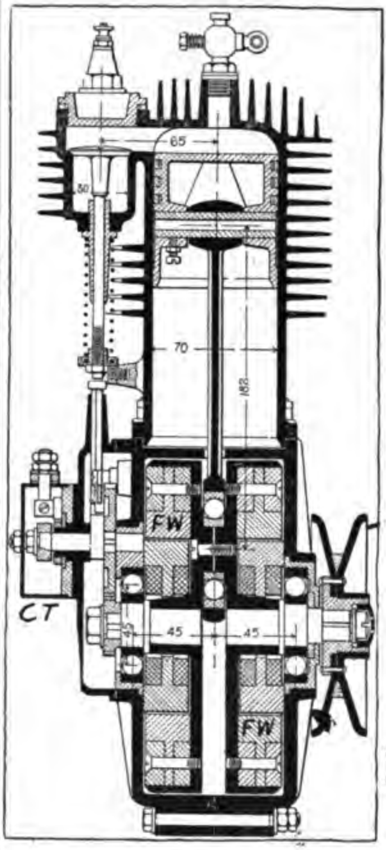


Fig. 1—The Air Cooled Flange Type of Cylinder. All Moto-cycle engines are air cooled.

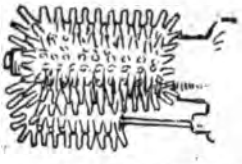


Fig. 2— The Old Style Knox "Porcupine" System of Air Cooling

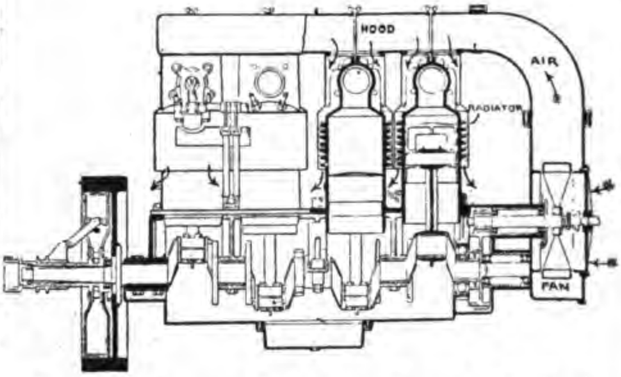


Fig. 3—Arrangement for Cooling a Four Cylinder Engine by Air Only, Using a Forced Draught, circulating through air jackets around cylinders which have a special radiating surface.

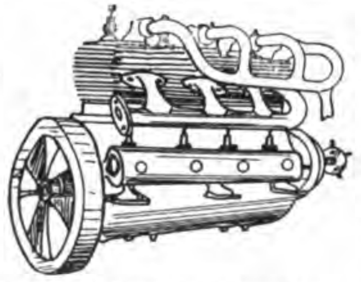


Fig. 4—A Four Cylinder, Air Cooled Engine

The Various Methods for Air Cooling

(1) By having a large radiating surface by means of cast flanges or gills, inserted pins and tubes.

(2) By using extra large exhaust valves, so as to cool the combustion space between power strokes.

(3) By combining large radiating surfaces with low speeds in multiple-cylinder engines.

(4) By the use of auxiliary exhaust ports, combined with surface radiation.

(5) By forced draught of air circulating through an air jacket around the cylinder.

The majority of air-cooled engines have rotary fans attached, for the purpose of increasing radiation with air currents at high speed.

CHART No. 125

The System Used on the Frayer—Miller Cars is to place a jacket around each cylinder, open at the bottom, and at the top being connected to a pipe from a centrifugal air blower driven by the engine. (Chart 125, Fig. 3.)

The Cylinders, heads and valve chambers are covered with flanges or studs, and the blast of air from the blower being directed against them carries off the heat.

Water Cooling at the present time is used more than air cooling, but the latter is being developed to so high a point that it would appear to be only a question of time before it is generally adopted.

Air Cooled Engines Have Small Cylinders, and must run at a high speed to develop their full power.

Because of the Fact that so exact a temperature cannot be maintained as with a water-cooled engine, they cannot be built for high compression, as there is danger from pre-ignition.

The Advantage of an Air Cooled Engine over one that is water cooled is that it has fewer parts; the water circulation system is entirely done away with, which means fewer moving parts to get out of order, and less weight.

The Air Cooled Engine Is Also Free From the Danger of Freezing in cold weather.

The Franklin Car is an example of a successful air cooled car. One of their good features are AUXILIARY EXHAUST VALVES which permit the cylinders to be cleared of the exhaust or burnt gas readily.

CARE OF THE WATER COOLED SYSTEM.

In the Winter Draw the Water if the cooling system is by water.

At the Lowest Point of the Pipe leading from the radiator to the pump, a tap is fitted.

When the Car Is Left for the Night in Frosty Weather, it is advisable to open this tap and to let all the water drain out.

When this has been done, the engine should be run for a few moments to make sure that all the water has been removed.

The Water in the Jackets of the Cylinder Heads is most conveniently removed by means of the syringe provided with the tool kit.

This Syringe Can Be Inserted Into the Jackets by removing the brass plugs in the cylinder heads.

In Winter, a Water Cooled Engine Must Be Carefully Guarded Against Freezing, for if the water freezes in any part of the system it will cause the breakage of piping or radiator, or crack a water jacket.

When the Engine Is Running, and the water warm, there is, of course, no danger; it is only when the engine is stopped that care must be taken.

When Leaving the Car For Some Time, the safest plan is to drain the water out of all parts of the system, cocks being provided for the purpose at the lowest point of the system.

FREEZING SOLUTIONS.

To Prevent the Water From Freezing when it is not desirable to drain it out, it may be mixed with wood alcohol, glycerine, or preferably, calcium chloride.

Calcium Chloride Should Be Dissolved in Hot Water in the proportion of four pounds to the gallon, and allowed to stand until it has settled.

This Should Be Used Instead of Plain Water, adding more solution to make up a loss by leakage, and water to make up the loss of evaporation.

Glycerine Is Used in the proportion of two pints to three pints of water, which makes a more expensive solution than calcium chloride and has a tendency to soften the rubber water hose.

Either of These Solutions will stand a temperature of 15 degrees below zero (F) without freezing.

There Are Several of Other Combinations of three or more elements such as 1-5 alcohol, 1-5 glycerine and 3-5 water; this latter combination is frequently used.

CAUSES OF TROUBLES OF COOLING SYSTEMS.

Assuming that the design and the construction of the engine, including all features of the cooling system, are correct, then, outside of leaks, insufficient water and bursting of the water jackets from freezing, overheating is the final result of all troubles from the cooling system; and overheating is due to either or all of three secondary troubles which may in turn originate from a number of primary causes.

The Three Secondary Causes of Overheating are impediments to either:

First, the circulation of the water through the system;

Second, the conductivity of the heat through the walls of the cylinders or radiator tubes;

Third, or the passage of air through the radiator and around the cylinders.

A List of the Primary Causes from which the above mentioned troubles derive their origin are as follows:

CAUSES OF OVERHEATING COMMON TO BOTH FORCED AND THERMO SYSTEMS.

INSUFFICIENT WATER SUPPLY IN RADIATOR.

CONSTRICTED HOLES IN GASKET WHERE PIPE CONNECTS TO CYLINDERS AND ON PUMP.

FRAYED HOSE CONNECTIONS.

INCRUSTATIONS OR LIME DEPOSITS ON WALLS OF CYLINDERS OR RADIATOR TUBES.

MUD BETWEEN FINS OR CELLS OF RADIATOR.

OVERHEATING CAUSES IN FORCED CIRCULATING SYSTEMS.

BROKEN FAN BELT.
FAN BELT TOO LOOSE.
TIGHT FAN BELT BEARING.
IMPROPERLY BENT FAN BLADES.
BROKEN PUMP SHAFT.
LOST PIN FROM PUMP SHAFT COUPLING.
LOST PIN FROM PUMP SHAFT GEAR.
LOST PIN FROM INTERNAL PUMP MECHANISM.

The Writer Knows of Instances where the pin holding the pump shaft to part inside of the pump being sheared off and the pump not working at all, yet the shaft would turn.

In Addition to These; overheating troubles have occured in cases where number plates have been attached to the front of the radiators so that they cut down their cooling efficiency; and there are cases where the mud pan was so closely fitted that passage of air through the radiator and around the cylinders was restricted so that overheating occurred; troubles of this sort are difficult to locate.

When Overheating Occurs from a restricted radiator it should be cleaned.

QUICK METHOD TO CLEAN RADIATOR.

At the Filling Orifice a gauge filter is provided to prevent any dirt passing into the tubes with the water.

Apart From Actual Dirt, however, there is apt to be a gradual incrustation of the system owing to deposition of the carbonates present in the water.

This Deposit Reduces the Efficiency of the radiator and may cause the water to boil, and the engine to be overheated in consequence.

This Incrustation is Particularly Liable to Occur in Distrcts where the water comes from limestone rocks.

If the Cooling System Is to Work Efficiently, this deposit must be removed at frequent intervals, and the easiest method of affecting this is as follows:

First of All it is necessary to remove all grease.

Put 1 Lb. of Soda to the Gallon of Water, run the engine until the water boils and draw off the water while hot.

Take Down the Radiator, wash out with clean water, also the engine jacket.

Fill the Radiator With Strong Spirits of Salts, let it stand for half an hour.

Obtain a Cork that will stop the bottom water outlet on the engine, then slowly fill up with spirits of salts; ten minutes is quite long enough to keep the acid in the engine.

Draw Off at the Bottom Outlet, and wash out engine and radiator with strong soda water to neutralize any acid left.

It Will Now Be Found quite free of fur or lime deposit.

It Is as Well to Keep a little soda in the water for a few days to neutralize any acid left, and which might eat away some of the solder of the joints.

The Process Is Quite Harmless to metal if care be taken to thorougly remove all traces of acid.

STOPPING SLIGHT LEAKS IN CYLINDERS AND RADIATORS.

The Act of Scouring Out the Circulation System With a Strong Alkali, Such as Soda Will Tend to Seal Up Any Very Small Leaks, and it might also be effective for a slight crack in a water jacket, as the soda, coming in contact with the iron, would form an insoluble filling and prove even better than rusting up the crack.

Radiator Leakages are Undoubtedly a Great Nuisance, as even when almost imperceptible, if the car stands for some hours, the loss of water is considerable, and serious risks may be incurred if there is not an ample supply of water for the engine.

The Standard Honeycomb Radiator Is Somewhat Prone to These Leaks; the metal is so thin and the joints so numerous, and it is not always possible to have a leak soldered up at the required time.

In This Case Recourse Can Be Had to a small but useful accessory as a leak preventer.

It Consists of a Couple of Small Plates or washers with a piece of sheet rubber fixed on; these plates have hooks so that a spiral spring can be fixed on to draw them together.

The Spring Is Threaded through the aperture at the leaky cell, the plates hooked on, and thus held firmly up against it.

Most Accessory Houses Keep Them, and if the car has a honeycomb radiator it pays to carry several of these devices.

The Construction of This Type of Radiator lends itself to a repair of this kind, but leaks in other forms of radiators, when they occur on the road, are rather troublesome.

Even Soldering them is by no means an easy job, there being such a large mass of metal that the solder cools as soon as it touches it.

A Good Plan is to carry a small box of white lead of a suitable consistency.

If the Water Is Not Coming Through quickly, a temporary repair can be made with this, especially if a piece of tape can by any means be bound over the repair.

It Is Often Possible to Hammer Up or Plug a leakage in a tank or radiator.

A Temporary Repair for a slight leak in a gasoline tank can be made by applying ordinary soap.

Such a Repair May Last till the defective part can be soldered.

Leaks at Gasoline Taps can generally be cured by screwing up the nut securing the tap plug, or by grinding in the tap with crocus and oil.

A Leakage of Water From the Jacket Into the Cylinder may be caused by a crack, but more usually will be found to be simply a defect in the seating of the plug fitted in the heads of many engines.

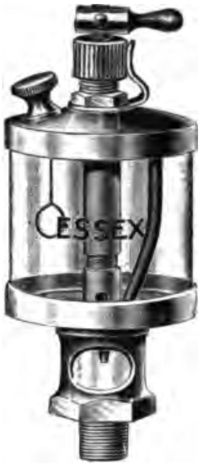


Fig. 1—Simplest Form of a Gravity Type of Lubricator.

Single Feed Type

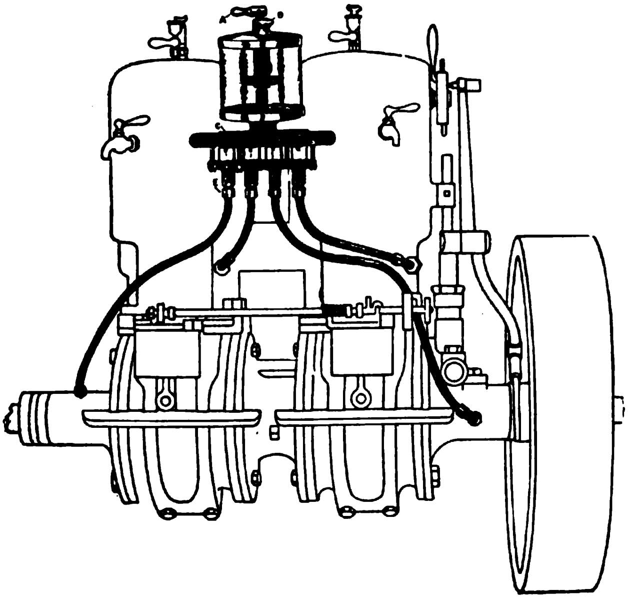


Fig. 2—Same Type of Lubricator as in Fig. 1 Attached to a Multiple Sight Feed Arrangement. The lubrication depends entirely on gravity.

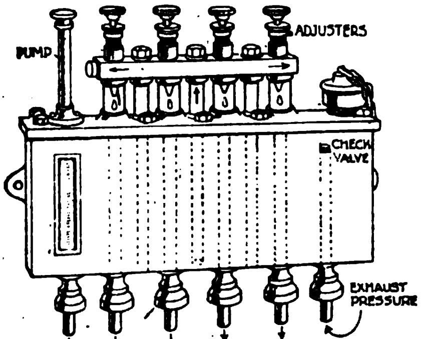


Fig. 3—A Combination of Gravity and Pressure.

This type of lubricator is usually placed on the dash. The box itself contains the oil, but the oil must pass through the glass sight feeds on top, thence through outlets, through small copper pipes to crank case and other parts of engine. To force the oil through the sight feeds requires pressure, therefore this pressure is obtained from the exhaust, similar to fig. 4 The hand pump is provided to occasionally throw a charge of oil into the crank case.

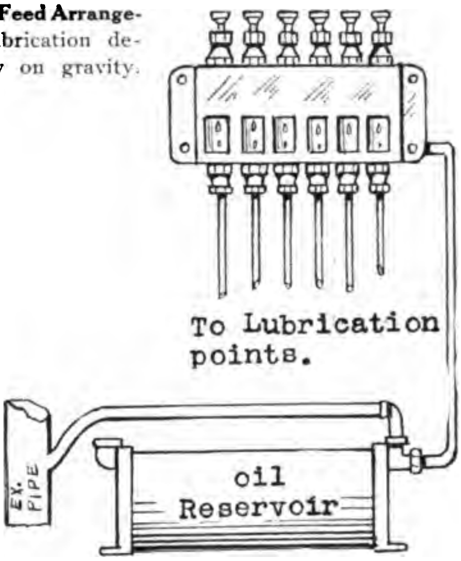


Fig. 4—Exhaust Pressure Feed Type of Lubricator

This type of lubricator consists of the following: An oil reservoir attached usually underneath the hood. A small pipe tapped to the exhaust pipe connects to a check valve (so pressure cannot get back). The pressure from the exhaust forces the oil to the sight feed arrangement, which is usually placed on the dash board. The oil then leads to the various parts of the engine through small copper pipes.

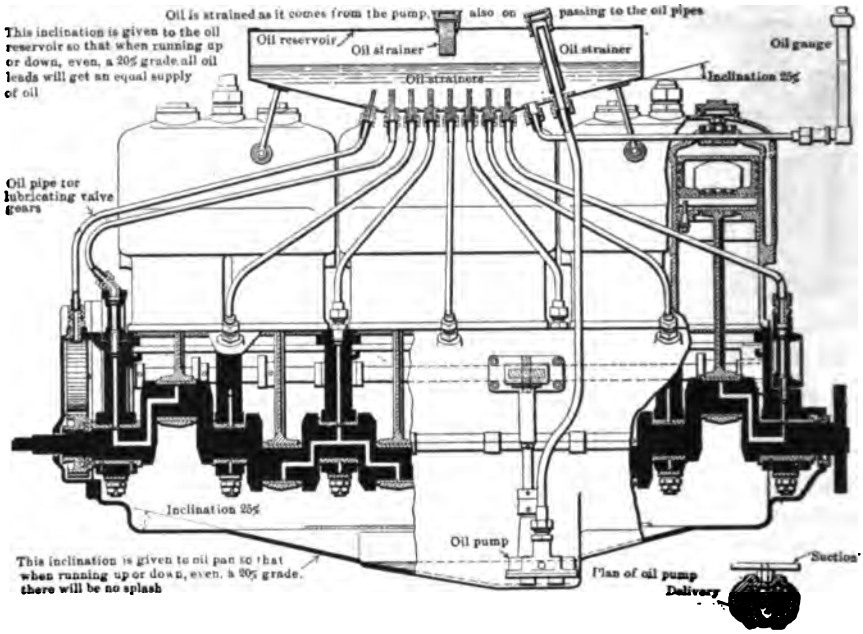

Oil is strained as it comes from the pump, also on passing to the oil pipes
This inclination is given to the oil reservoir so that when running up or down, even, a 20% grade all oil leads will get an equal supply of oil
Oil reservoir
Oil strainer
Oil strainer
Oil strainers
Oil gauge
Inclination 25%
Oil pipe for lubricating valve gears
Inclination 25%
Oil pump
This inclination is given to oil pan so that when running up or down, even, a 20% grade, there will be no splash
Plan of oil pump
Suction
Delivery

Fig. 1 — A Modern Force Circulating Oiling System

The oil reservoir is placed at the top of the engine as shown. The oil pump is driven from cam shaft and forces oil from crank case back to oil reservoir and is then used over and over again.

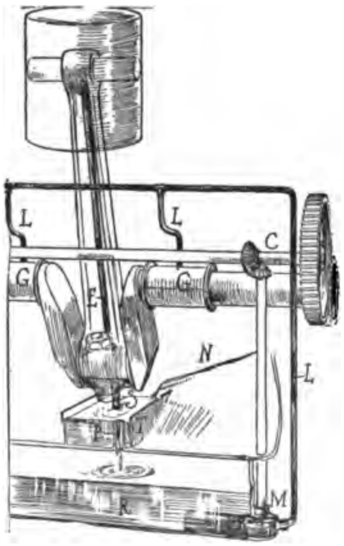


Fig. 2 — View Showing How the Oil is Splashed by the End of the Connecting Rod.

A circulating oiling system is one in which the oil which is fed to the bearings is used over and over again; means being provided to collect all superfluous oil and return it to a reservoir from which a pump is employed to again force it to the reservoir from which it flows by gravity or splash to the bearings. The operation of a typical circulating oiling system is shown in Fig. 1 and 2; the main oil supply is contained in the reservoir R, from which it is drawn by the pump M and forced through pipes or leads L to the main crankshaft bearings G.

The overflow from these bearings is thrown by centrifugal force against the walls of the crankcase and cylinders and, as it runs down, is collected by inclined channels N which conduct it to troughs T.

For lubrication of the connecting-rod bearings, scoops S are fitted to the lower ends of the connecting-rods, which dip into the oil contained in the troughs and scoop it up into the crankpin bearings at the lower ends, and through tubes E running up the rods to the piston-pin bearings.

Overflow pipes P are provided in the troughs T so that the excess oil can return to the reservoir R.

The pump M is operated by bevel gears and vertical shaft from the camshaft C.

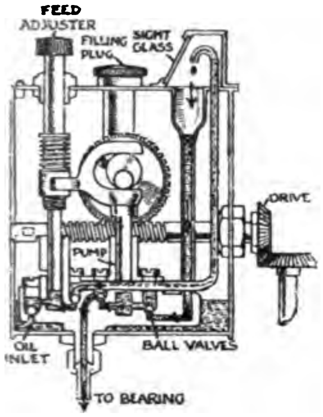


Fig. 1 — Mechanical Pump Lubricator, with plunger pump and sight glass. The oil is pumped up to the sight and thence pumped direct to the bearings. It is power driven.

Power Driven Pump Oiler

This type of oiler is usually placed on the dash or any convenient point so that it can be driven either by a belt or a gear.

There are several small pumps inside of the oil reservoir, in fact there are as many pumps as there are feeds.

Each separate feed is piped to different parts of the engine.

A small pump forces the oil through each feed.

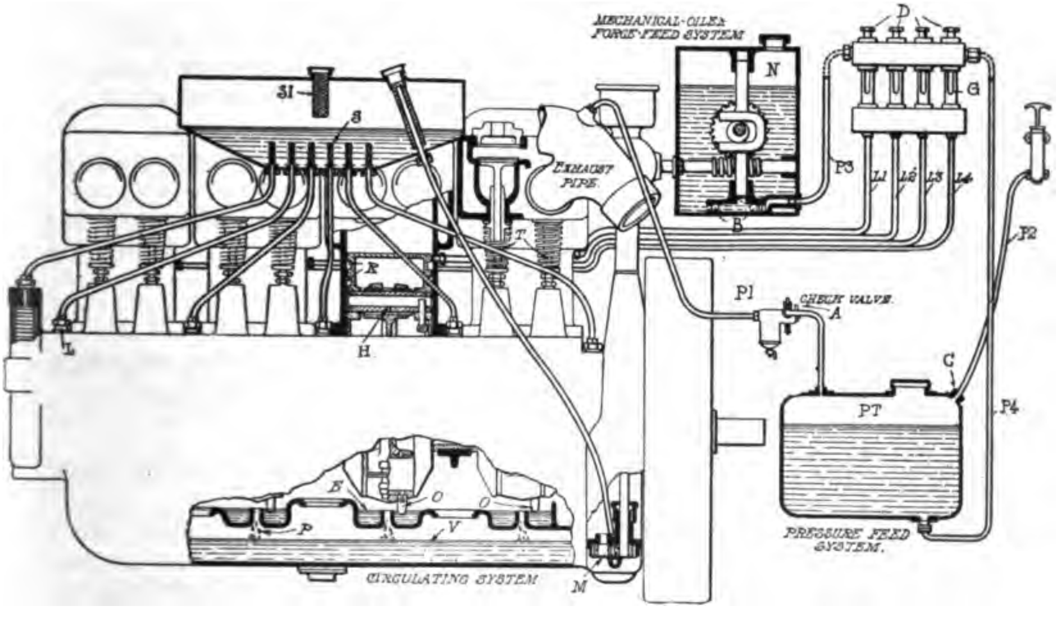


Fig. 2—Illustration Showing the Three Systems in General Use, on One Engine, in Order to Clearly Explain Each System

First: On the above engine we have the combination system of gravity, splash, and forced circulation system as shown on chart.

The oil is originally placed in reservoir through strainer S1, it is fed by gravity to the bearings and crank case. The bottom of crank case is filled to a certain level and then overflows into oil reservoir underneath the crank case.

The oil is then pumped back into reservoir by pump M.

Note the end of the connecting rod O, which splashes in the scoop provided, E.

When this oil in bottom of crank case reaches a certain height it overflows into oil reservoir through pipe P.

Second. The second system is the Force Feed mechanical oiler explained in Fig. 1.

Third. The third system is the Exhaust Pressure feed system. A hand air pump is also shown P2.

INSTRUCTION No. 26

LUBRICATION:—Oil Bath. Grease Lubrication. Splash. Gravity. Force Feed. Circulating Oiling System. Lubricants. Lubricating Troubles. Cause and Effect.

LUBRICATION.

When Two Parts of a Mechanism Rub Together, it is necessary to use some means of preventing excessive friction, and this is usually done by applying lubricating oil between them.

Without a Lubricant the Friction Would Cause Heating, and the result would be cuts or scratches on the surfaces of the two parts.

Two Parts Intended to Rub Together, like a shaft in its bearing, should be made as smooth as possible, for roughness would cause friction that lubrication could not prevent.

The More Rapid the Movement of the Parts Against Each Other, the more they must be lubricated.

A Bearing in Which a Shaft Is Turning at a constant speed requires a constant supply of oil, which must be fed to it regularly as required.

Too Much Oil Would Be Wasteful, and too little would permit the bearing to become heated.

All of the Moving Parts of an automobile must be lubricated, but as some parts move much faster than others, the kind of lubrication must be varied to suit each.

METHODS OF LUBRICATION.

The Methods of Lubrication May Be Divided into five classes:

(1) **Oil Bath,** in which the enclosing of the moving parts in a tight case permits them to run in oil.

(2) **Grease Lubrication,** for slow moving parts, the parts being packed in heavy grease.

(3) **Splash Lubrication,** in which a moving part splashes into a bath of oil, spattering it to the surrounding parts of the mechanism.

(4) **Drip Lubrication,** in which the oil drips by gravity from an oil cup onto the part that is to be lubricated.

(5) **Force Feed,** or pressure lubrication, in which a small pump operated by the engine forces a fixed amount of oil through a pipe to the bearing to be lubricated.

OIL BATH LUBRICATION.

The Change Speed Gears Are Usually Lubricated by an Oil Bath, the gear case being tight to prevent leakage.

The Case Is Filled With Oil to such a point that the largest gears dip into it about an inch, and their revolution, with the splashing that it causes, keeps all of the gears lubricated.

GREASE LUBRICATION.

Grease Lubrication Is Used for the Differential, universal joints, steering mechanism, and other similar parts.

These Are Usually Enclosed either in metal casings or leather pockets, and are thoroughly packed with grease.

Grease Is Also Used for the Lubrication of Wheels and other parts, being contained in cups so arranged that a spring forces the grease slowly through an opening to the bearing.

SPLASH LUBRICATION.

Splash Lubrication is usually used for the lubrication of the crank shaft, piston and cylinder walls, and connecting rod and wrist pin bearings.

The Crank Case Is Made Oil Tight, and oil is placed in it to such a depth that the end of the connecting rod dips into it about one-half an inch.

In Its Movement, the connecting rod splashes into the oil, and splatters it to all parts of the crank case, the bearings, and the lower parts of the piston.

An Oil Groove is cut around the lower part of the piston, and the oil splashing into this is carried upward and distributed on the cylinder wall and rings.

When the Oil Is Used, more must be added to the crank case to keep it to the necessary level.

This Is Done Either by Means of a Hand Pump Connecting the Crank Case to the Oil Tank, by an oil cup that drips a certain amount of oil into the crank case every minute, or by connection with the force feed lubricator.

With the Hand Pump, the driver gives it a stroke or two every few miles, experience being his guide as to how often and how much.

DRIP OR GRAVITY LUBRICATION.

In the Drip System, an oil cup is provided for every bearing or part that is to be lubricated.

The Oil Is Poured Into Them by an Opening at the Top, and flows out by gravity through an adjustable opening at the bottom.

In the Drip System, the oil flow is not controlled by the engine, and each cup is therefore provided with a cock by which the oil may be turned on when the engine is started, and turned off when it is stopped.

FORCE FEED SYSTEM.

PUMPS IN THE LUBRICATOR MECHANICALLY OPERATED

In the Force Feed System, the engine drives a pump, or several pumps, which are located in a tank filled with oil.

Each Pump Is Connected to a Bearing by a Fine Tube, the oil being forced through the tube as the pump operates.

The Faster the Engine Runs, the faster the pumps are operated, and consequently, the more oil is pumped to the bearings; when the engine stops, the flow of oil stops also.

Each Pump Is Adjustable, so that the amount of oil it delivers may be regulated according to the work that it is to do.

Each Pump Is Usually Provided With a Short Glass Tube, so that the flow of oil may be watched; if the passage becomes obstructed, the oil ceases to flow through the tube, and as this, called the SIGHT SEED glass, is located on the dash, the driver may see whether or not it is operating correctly.

The Pump Is Driven By a Belt, or an arm operated by the engine.

The Bearings That Are Fed by a Force Feed Lubricator are the main bearings of the crank shaft, the cam shaft, and in addition the crank case, which is kept filled to the proper point.

In Some One-Cylinder, and many of the multi-cylinder engines, the cylinder walls and pistons are lubricated by the force feed oiler in addition to the splash.

The Connection From the Lubricator passes through the cylinder wall at the lower point, and the oil that feeds through it is caught by the oil groove on the piston.

Manufacturers Always Provide a table that gives the number of drops of oil to be fed to each part per minute, and it is best to be guided by it until experience teaches otherwise.

LUBRICANTS.

Lubricating Oils Are of Various Classes, according to their fluidity, some oils being more liquid than others.

A Further Difference in oils is shown by their FLASH POINTS and BURNING POINTS.

When a Lubricating Oil Is Heated to a certain point, it will give off a thin smoke.

If a Lighted Match Is Touched to It, the smoke will take fire with a quick flash.

This is called the flash point.

On Heating the Oil Still More, the oil itself will finally take fire and burn, and the temperature that will permit this is called the burning point.

The Flash and Burning Points are much higher in some oils than in others.

If Oil With a Low Burning Point Is Used in the cylinder of a gasoline engine, the intense heat will burn it before it can lubricate the cylinder walls and piston.

If Oil of a Sufficiently High Burning Point Is Used, the temperature of the cylinder will not be high enough to burn it, and the cylinder walls and piston will be properly lubricated.

Oil of the Best Grade, especially made for the purpose must be used in the cylinder to get good results from the engine.

Any Oil, no matter how thick and heavy it may be, will become thin when it is heated.

RESULTS OF USING A POOR GRADE OF OIL.

If the Heating Is Continued, the oil will be vaporized, or turned into gas.

When This Occurs, such oils as are ordinarily used for gasoline engines will leave a deposit of carbon on the piston and spark plug.

This Carbon Will Be Gummy at First, but when dried it becomes hard and difficult to remove.

It Can Be Understood That This Might Interfere With the Operation of the Engine, the gummy or hardened deposit preventing the piston from sliding easily.

This Deposit Will Result from the use of a poor grade of oil, and it is by all means best to use the best oil possible to obtain.

Too Much Oil Interferes With the Operation of the Engine, for it works above the rings, and short circuits the spark plug.

When in the Combustion Chamber the heat will burn it, and cause an offensive smoking at the exhaust.

Because Oil Becomes More Fluid when it is heated,the oil feeds should be adjusted after the engine has been running, for if adjustments are made for cold oil, the flow will be much more rapid when it is warmed, and the bearings will be flooded.

RESULTS OF NOT USING ENOUGH OIL.

If the Engine Is Not Getting Enough Oil, the cylinder will become so hot that any oil that may have splashed on its outside will be burned —the smell being an indication of the condition.

Further Running Without Oil will produce a hard metallic knock, and the heat will finally cause the piston to stick in the cylinder.

An Engine That Is Run Without Oil Will Be Ruined, for the piston rings and the walls will be cut and scratched lengthways, so that the compression will not hold.

If the Piston Sticks for this reason, pour a little kerosene into the cylinder, and crank the engine to distribute it over the walls and rings.

This Will Free the Rings from the gummy carbon deposit, and after cooling the engine may be started again.

A New Bearing, or any other new part that has not worn smooth, requires more oil than one that has been run.

It Is Always Better to Give a Bearing Too Much Oil Than Too Little, but the exact amount of oil required for each part of the car should be learned as quickly as possible, in order to prevent waste.

HOW TO TEST LUBRICATING OILS.

Acid Test. A Very Simple Test to detect acid in an oil is with Blue Litmus Paper, which will show a pinkish color if there is any acid present.

Another Sensitive Test, and a very practical one, is to partly cover a polished steel plate with a strip of flannel or lampwick saturated with the lubricant to be tested.

Expose This to the Sunlight for About Twenty-four hours.

When the Plate Is Wiped Dry if the lubricant is free from acid the steel will have retained its gloss.

If Dull Spots Have Developed on the surface covered, it is the sign of the presence of acid.

Flash Test. It Is a Comparatively Simple Matter to take a flash test of an oil by heating a small quantity in a porcelain vessel over a Bunsen Flame, stirring the oil with a thermometer and applying a lighted match to the surface of the oil occasionally.

When a Bluish Flame Spreads Over the Liquid and dies out quickly the temperature should be noted, for this is the flash point. From about 410 to 420 degrees Fahr. is a proper flash point.

No Cylinder Oil Should Have a Flash Point Lower Than 400 Degrees Fahrenheit, nor higher than 450 degrees Fahrenheit. The viscosity should not be lower than 200 at 70 degrees Fahr., nor higher than 500.

LUBRICATING TROUBLES: CAUSE AND EFFECT.

In Order That the Lubrication of a Motor Be Perfect, it is necessary that a required supply of oil be fed to all parts; and failure to supply these parts with proper portions of oil results in trouble of a more or less serious nature.

In Locating and Correcting Motor Car Troubles, it is imperative that the source of the trouble, as well as the trouble itself, be given attention, if the repair is to be successful; and as faulty lubrication is the fundamental cause of many kinds of motor trouble, a list of possible troubles may be at some time of assistance to the repairman, be he amateur or professional.

Most Lubrication Troubles Are Due to Either too much oil or too little, and the following is a list of the troubles brought about by them.

EFFECT—TOO MUCH OIL.

MUFFLER CLOGGED, LOSS OF POWER.
CARBON ON VALVE-STEMS, STICK IN GUIDES.
OVERHEATING FROM PREIGNITION.
CARBON IN CYLINDERS AND PREIGNITION.
KNOCKING FROM PREIGNITION.
SMOKY EXHAUST.

INSUFFICIENT OIL SUPPLY.

OVERHEATING FROM EXCESSIVE FRICTION.
PREIGNITION FROM OVERHEATING.
KNOCKING FROM PREIGNITION.
LOSS OF POWER, EXCESSIVE FROM FRICTION.
SEIZED BEARINGS.
SEIZED PISTONS.
SCORED CYLINDERS.
KNOCKING FROM WORN BEARINGS.
POOR COMPRESSION, OIL TOO LIGHT.

CAUSE—TOO MUCH OIL.

OIL RESERVOIR TOO FULL.
OIL FEEDS IMPROPERLY ADJUSTED.
HEAVY OIL REPLACED BY LIGHTER GRADE.
BAFFLE PLATES LEFT OUT OF CYLINDERS.

INSUFFICIENT OIL SUPPLY.

NOT ENOUGH OIL IN RESERVOIR.
OIL FEEDS IMPROPERLY ADJUSTED.
LIGHT OIL REPLACED BY HEAVIER GRADE.
OIL FEED PIPES STOPPED UP.
LEAK IN PRESSURE PIPE.
LEAK IN OIL LEAD.
PRESSURE VALVE OUT OF ORDER.
LACK OF PRESSURE IN TANK.
STRAINER STOPPED UP.
OILER DRIVE-SHAFT, BELT OR CHAIN BROKEN.
OILER DRIVE-SHAFT, BELT OR CHAIN LOOSE.

The Only Place Where Too Much Oil Is Harmful in a Motor Is In the Cylinders, where it is burnt with an excessive precipitation of carbon that adheres to the piston and cylinder heads, lodge on the valve-seats, causing preignition, overheating and knocking, loss of compression, and passes off into the muffler, clogging it, giving off much objectionable smoke, and ultimately reducing the efficiency of the muffler to such an extent that the back-pressure causes a noticeable loss of power.

The Local Remedy for these is to scrape and cleanse the cylinders, grind the valves, clean the muffler, and then find the cause of the excessive oil supply and cut it down.

Too Much Oil, in a circulating system in which the oil is simply drawn from the reservoir and forced into the splash-compartments of the crank-chamber, is caused only from an excessive supply in the reservoir, or improper design.

In the Circulating System Shown in Fig. 1, Chart 128, the oil level in the reservoir should be about as at V, so that the level in the scoop or splash compartments E may be maintained.

If the Supply in This Reservoir Is Insufficient, the supply in the splash or scoop compartments would also be insufficient, and overheating and damage to the various bearing surfaces would take place.

In the More Complicated Circulating System, where the lubricant is conducted from the sump of the crankcase and forced up into a tank from which it flows by gravity through leads to the crankcase bearings, the strainer S1 should not be removed when refilling the tank, to hasten the operation; if the leads from the tank should be loosened for any reason, the strainers S should be properly replaced and all connections thoroughly tightened. A leak, for instance, at the point L might cause the front main bearing to run hot and seize or score the shaft, in which case a very expensive repair would be the result. Such leaks rarely occur, but they are possible, and the example is given to impress one with the fact that a leak is not to be overlooked.

The Leads L1, L2, L3 and L4 of a Pressure or Mechanical Force-Feed System are also liable at times to spring a leak or become clogged up.

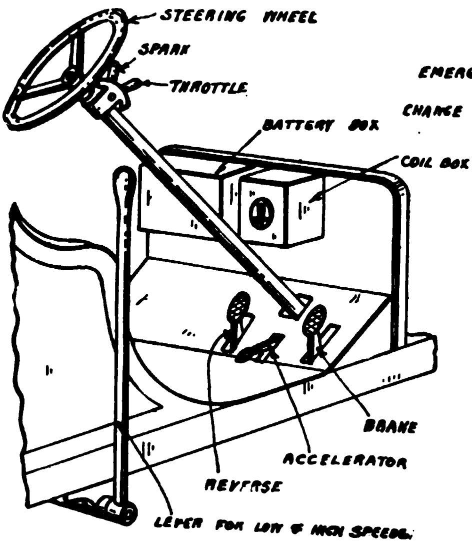


Fig. 1 - Car With the Planetary Transmission

Usually has but one lever. When this lever is pushed forward it is on the "high gear" and when pulled back it is on the "low gear." When in the center it is on "neutral."

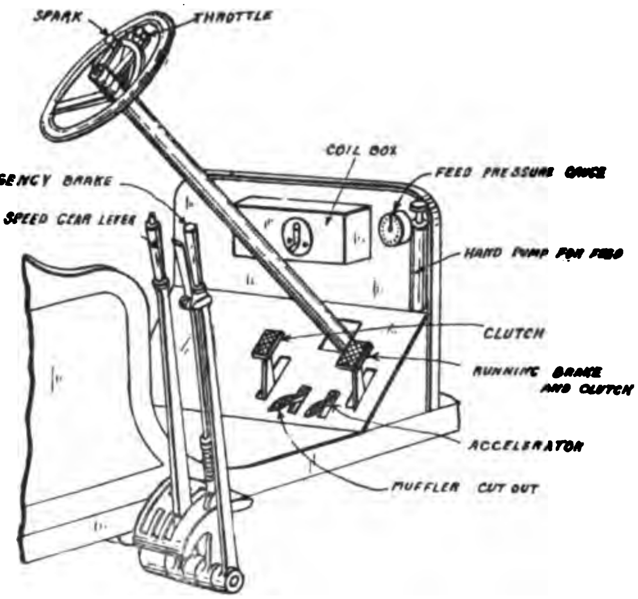


Fig. 2—Car with the "Selective" Type of Transmission

This is the type most generally in use.

The outside lever is the emergency brake lever.

The inside lever shifts the gears as explained in Chart 133-134

The emergency brake lever is used only occasionally, as the foot brake answers for all ordinary work. The emergency brake is always thrown on when leaving car stand.

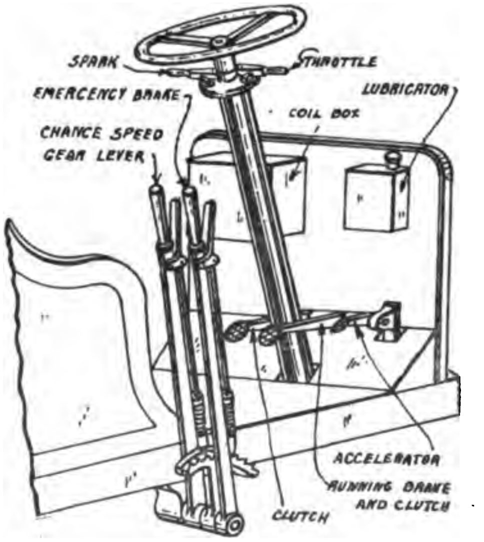


Fig. 3—Car with the Old Style Progressive Type of Transmission

The outside lever is the emergency brake lever and the inside lever changes the gears. See explanation in Chart No. 23

CHART No. 129

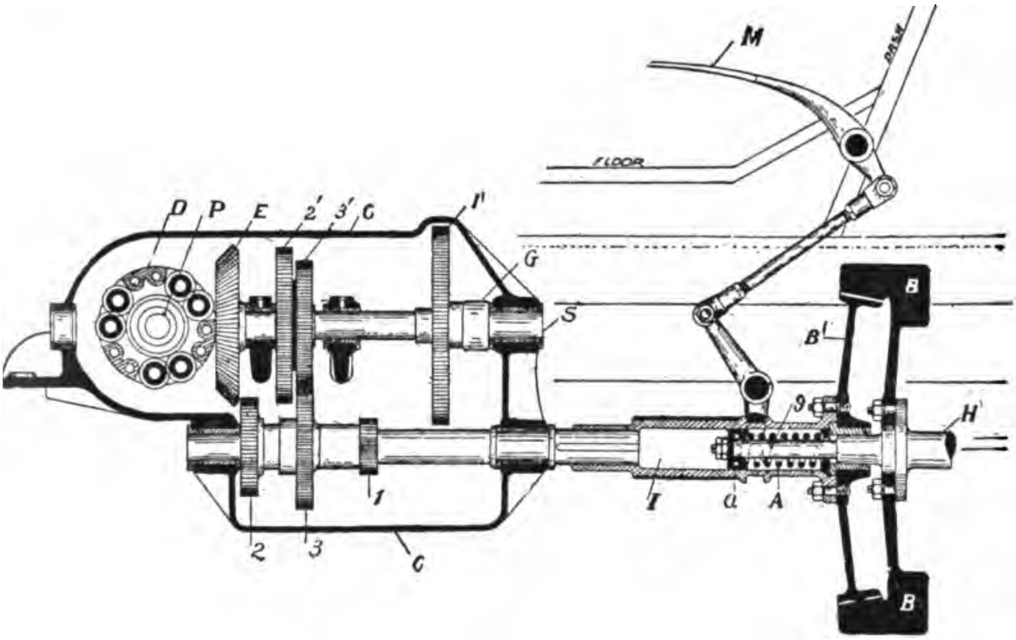


Fig. 1—Illustration Showing the Clutch Pedal and its Purpose

The clutch pedal is used probably more than any other part of the car and its purpose and principle should be studied carefully.

M— Clutch Pedal. B^1 —Clutch. B— Fly Wheel. H— Engine Shaft. P— Rear Axle. S—Secondary shaft driving rear axle through bevel gear E.

NOTE: When the change gear speed lever is in neutral position, this means that the lever has placed the gears in the transmission in a "neutral" position. In other words the gears are thrown out of mesh, therefore the engine could be running and the clutch be "in" yet the car would not move, because the gears would not mesh and the drive shaft in the transmission would be running free, for instance suppose gear 3 was moved just far enough forward to take it out of mesh with gear 3^1, it will readily be seen that the shaft S would not be driven.

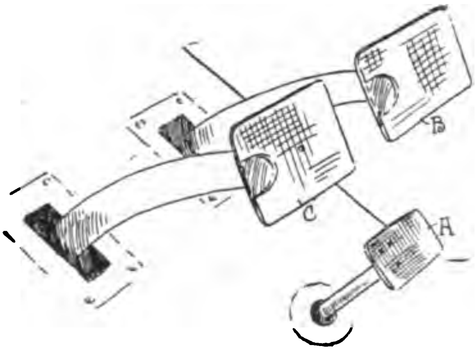


Fig 2—The Clutch Pedal, the Brake Pedal and the Accelerator Pedal

The brake pedal is also used to a considerable extent. The driver in slowing down or turning curves, usually "throws out" the clutch pedal, thereby releasing the power on the rear axle and applies the foot pedal brake gradually. The brake pedal is never applied when the clutch is "in."

The usual position for the clutch pedal C is on the left and the brake pedal B is on the right. The pedal A is the accelerator and is explained in Chart 40.

INSTRUCTION No. 27

OPERATING A CAR: Starting the Engine. Running the Engine. Operating the Planetary Transmission. Operating the Gear Transmission. Steering a Car. Changing Speeds. Control of the Speed. Throttle and Spark Lever. Foot Pedal. The "Selectors" of Various Cars.

OPERATION.

In Learning to Operate an Automobile, the first step is to become familiar with the control of the speed.

The Simplest Way in which this can be done is to jack up the rear wheels so that they are clear of the ground, letting the weight of the car rest on a solid box.

The Point Is to Get the Driving Wheels Clear of the Ground, and free to revolve without moving the car.

The Different Speeds May Then Be Handled, and the movements of the levers and pedals gone through with, without being under the necessity of steering.

Care Should Be Taken to Block the Front Wheels, so that the vibration of the engine cannot shake the car from its support.

STARTING THE ENGINE.

Put On the emergency brake.

Set the Change Speed Gear in the "**Neutral**" position.

Turn on the Lubricating Oil, if the gravity system is employed.

Turn on the Gasoline so that it flows to the carburetor.

Open the Throttle slightly.

Place the Spark Lever in the Retard Position; DO NOT OVERLOOK THIS.

The Throttle and Spark Levers Are Usually on the Steering Column: the book of directions furnished by the makers of the car shows their arrangement.

Prime, or "Tickle," the Carburetor, which permits the float chamber to fill.

Too Much Priming Will Flood the Carburetor, and may give so rich a mixture that the engine will not start.

Switch On the Ignition circuit.

Crank the Motor, and if it is in good condition it will start as soon as the piston, or one of the pistons, has gone through the suction and compression strokes.

When Starting the Engine for the First Time, it is well to go through the motions of cranking before the ignition circuit is switched in, in order to become familiar with the "feel" of it.

A Four or Six Cylinder Motor May Sometimes Be Started without cranking.

The Chances Are That in One of the Cylinders the piston will have the charge under compression.

Switch on the Current, and move the spark lever from one end of its arc to the other.

This Will Produce a Spark in the cylinder holding the compressed charge, and when this is ignited the pressure will start the engine.

In Starting the Motor With the Crank, it should be running after six or eight turns of the crank; if not, something is the trouble, and this should be located.

Prime the Carburetor Again, and crank, and in cold weather it may be necessary to do this several times, as the gasoline does not vaporize freely.

If the Motor Refuses to Start, investigate the cause.

RUNNING THE ENGINE.

When the Engine Starts, advance the spark slowly until a knocking sound is heard in the cylinder, and then draw it back slowly until the knock ceases, when the engine should be running smoothly.

Open the Throttle a Little, and experiment will show that the spark may be advanced further without the knock occuring than it could with the smaller quantity of mixture.

Closing the Throttle reduces the speed of the engine, and retarding the spark makes it run still slower.

Experiment Will Show that for each position of the throttle there is a certain position of the spark that gives the greatest speed to the engine.

The Two Act in Relation to Each Other, depending on the quality of the mixture and the rapidity with which it burns, and the greatest efficiency of the engine is obtained by observing this relation.

Always Throttle the Mixture BEFORE RETARDING THE SPARK, and DO NOT ADVANCE THE SPARK BEFORE FIRST OPENING THE THROTTLE. (See Chart 40A.)

In Learning to Control the Speed of the Engine by Spark and Throttle, do not let it race; that is, get to a high speed, for it will cause great vibration, and may cause strains and injury.

When the Operation of the Engine Is Understood, the change speed gear must be learned.

The Spark Should Not Be Retarded Too Much at Any Time, whether going up or down hill or on a level.

If the Spark Is Cut Off When a Car Is Coasting, a muffler shot will be generated when the spark is thrown in again and the accumulation of mixture in the muffler and exhaust piping may be sufficient to disrupt the muffler.

Running on a Retarded Spark Causes Undue Heating of the automobile engine, and the exhaust valve is likely to be warped as well.

OPERATING A CAR WITH A PLANETARY GEAR.

A Planetary Change Speed Gear Is the Simplest to Handle, as the clutch and speed changes are controlled by one lever. (See Chart 129, Fig. 1.)

When the Lever Is in the "Neutral" Position the gears, while turning, do not transmit the power of the engine to the wheels. This lever must be kept in this position until car is started.

Take the Driver's Seat, and increase the speed of the engine by spark and throttle, but be careful not to let it race.

Move the Speed Lever Backwards to bring the low speed into action, and in most cases it will be held in that position. (On some cars with planetary transmission this lever is moved forward for low speed.)

Most of the Running Is Done on High Speed, the speed of the car being controlled by controlling the speed of the engine.

When Running on the Road, and it is necessary to slow down, merely throw the lever to the center or "neutral" position.

***To Reverse,** bring the lever back to the first neutral position, and then, when the wheels have stopped, put the foot on the reverse pedal, when the wheels will revolve in the opposite direction.

OPERATING THE GEAR TRANSMISSION.

†Take Your Position in the Car, place the speed gear lever in the "neutral" position, and release the brakes or throw the clutch, according to the arrangement of the car. (See Chart 129, Fig. 2.)

Practice Pressing the Clutch Pedal and Releasing It, until the feel of it is understood.

The Pedal Should Be Depressed Sharply, and released slowly, which throws out the clutch quickly, and throws it in slowly.

Do This a Number of Times, until it becomes natural and well understood.

Speed Up the Engine Slightly, throw the clutch out, and move the control lever forward to the notch that indicates the SLOW speed.

Let the Clutch In slowly.

The Clutch Must Be Permitted to Take Hold Gradually—let it slip a little at first, to pick up more and more of the load, so that finally it turns the wheels steadily.

When the Clutch Has Taken Firm Hold, throw it out, and move the control lever back to the neutral position.

These Motions Should Be Gone Through a Number of Times, until familiarity with it makes the gears and clutch go in and out of engagement smoothly.

***Get the Wheels Going on Low Speed,** and then move to the intermediate or second speed.

Throw the Clutch Out, move the control lever to the next notch, and let the clutch in slowly.

If the Gears Do Not Go Into Mesh Easily, but grind and growl, try it over gain, coming back to low speed first.

Never Try to Force Them, for if they do not go into mesh easily, it indicates that the countershaft and square shaft are moving at such different speeds that it might strip the teeth.

The Speed of the Engine Should Be Controlled until the gears on the countershaft and square shaft are revolving at the same speed, when of course they will mesh easily.

When the Change From Low to Second Speed is well understood, and can be performed smoothly, move from second to high, increasing the speed of the engine sufficiently, and being sure to first throw out the clutch.

IMPORTANCE OF THE CLUTCH.

It Will Tear Things to Change Speed Without First Throwing Out the Clutch, for the wheels will be moving the square shaft at one speed, and the engine will be driving the countershaft at a different speed, so that in meshing the gears there will be no loose gear to change its speed according to the speed at which the other is moving.

---

*See Chart No. 24 for explanation of the Planetary Transmission.

†See explanation of neutral position in Chart 130.

*See Chart 134 explaining the various changes of speeds in different cars.

Complete Familiarity with the motions of going from one speed to another and back again should be acquired before attempting to run on the open road.

Always Throw the Clutch Out Before Changing Speed.

The Reverse Should Be Handled in the Same Way, remembering to bring the rear wheels to a dead stop before throwing the clutch in.

When the Control of the Engine and Change Speed Gear Is Well Understood, the first run on the road may be made, but first study the rules of the road. (See Chart 169.)

STEERING A CAR.

A Very Slight Movement of the Steering Wheel or Lever Is Sufficient to turn the car, and too sudden a turn may cause an upset.

Select a Straight Road, as wide as possible, and with the engine running slowly, throw in the low speed.

The Car Will Move Forward Slowly, and it will then be necessary to steer.

The First Inclination Will Be to Grip the Wheel as tightly as possible, but after a little running a light grip will be found sufficient.

At This Stage it is necessary not to get rattled.

If the Car Begins to Run Off the Road, or into an obstruction, throw out the clutch so that it comes to a standstill.

When the Excitement Has Died Down, try again, and it will not be long before steering comes easily.

There Is No Time Lost between the turning of the steering wheel and the turning of the car; when taking a corner do not move the wheel until the car is at the point where turning is necessary.

CHANGING SPEEDS.

Take Plenty of Time, and do not attempt second speed until steering on the first is smooth.

When Running on Low and Second Speeds, the engine speed should be as low as possible, to keep it from overheating.

After Much Running on Low Speed, the engine will probably heat in any case, so that there should be a rest every little while, or else the water may be drained off and fresh, cool water poured in.

In Going to Second Speed, the change should be made quickly in order that the car may not slow down so much that the gears would not mesh.

With Practice, the speed of the engine may be kept in accordance with the speed of the square shaft, so that the gears will mesh without grinding, but the clutch should be let in slowly, so that there may not be a jerk.

The Same Applies in going from second to high speed.

A Car Is Usually Run on High Speed, because then the engine is running slowly in relation to the speed of the car.

The Best Driver Gets the Greatest Distance With the Fewest Revolutions of the Engine, which means less wear, and less fuel and oil.

The Lower Speeds Are Principally Necessary For Hill Climbing, for which the engine must have more pull on the wheels to take the car up.

Do Not Pick Out a Very Steep Hill for the first attempt.

The Motor Should Be Running at Good Speed by control of the spark and throttle, and the high speed gears engaged.

As the Car Ascends the Hill, the motor will begin to slow down as it feels the load.

Retard the Spark Gradually, to keep the motor working smoothly, but when the engine has slowed down, and shows signs of distress, it is time to change to second speed.

The Change Must Be Made Quickly, for if time is wasted over it, the car will slow down so much that it will be necessary to drop back to low speed.

Push Down Sharply on the Clutch Pedal, bring the speed control lever back to the second speed notch, and let the clutch in slowly.

Do Not Get Rattled and Let the Clutch in With a Jerk, for the load thus being thrown suddenly on the engine would probably stall it.

In This Event, the car will begin to run down the hill backward, and the emergency brake must be thrown on to hold it.

If, as Is Often the Case, throwing on the emergency brake also throws the clutch out, get out of the car and block the rear wheels, so that the brake may be released and so that you can start again.

Put the Control Lever in the Neutral Position, start the motor, engage the low speed, and start the car again.

Do Not Change Speed if the Motor Is Taking the Hill Comfortably, and do not rush things.

If the Speed Must Be Changed, do not lose time in doing it.

A Car Will, of Course, Go Up Hill More Easily With a Light Load Than With a Heavy, so that in changing speed the load must be taken into account.

COASTING.

While the Speed of the Car in Going Down Hill may be kept under control by the brakes, it is better to use the motor as a brake.

This May Be Done by switching off the ignition.

The Motor Is Then Being Driven by the forward movement of the car.

The Effect Is to Convert the Motor Into an Air Compressor, and the resistance it will present will keep the car in check on all but the steepest hills.

This Will Cool the Motor, and also save the brakes, which on a long hill are liable to be burned and ruined.

IF THE BRAKES FAIL.

If the Engine Stalls While Ascending or Descending a Hill, the brakes should be thrown on at once to keep the car under control.

If Poor Adjustment of the Brakes Renders Them Insufficient for This, jump out and block the wheels with anything that is handy.

If the Car Is Moving Too Fast for This, stick to the wheel and if it is possible steer the car down hill, keeping the horn going.

It May Be Possible to Steer It Off the Road Into a Bank or Other Obstruction that will stop the car without too much damage to it or its occupants.

Situations Such as This Require a Cool Head and Steady Hand, and the more the experience in operating that the driver has, the greater are the chances for handling it in the right way.

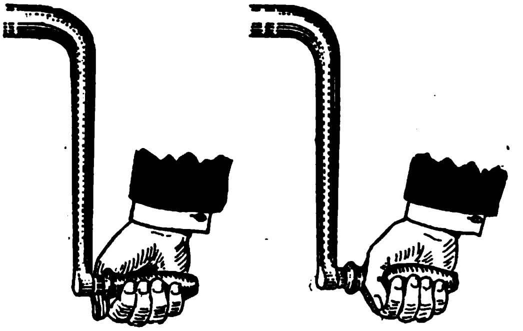


Fig. 1 Fig. 2

How to Hold the Crank Correctly and Incorrectly. Fig. 1 is the Correct Way

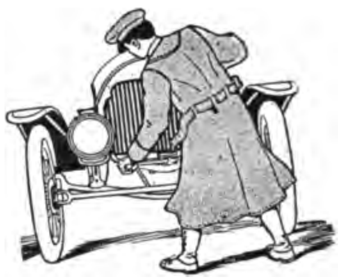
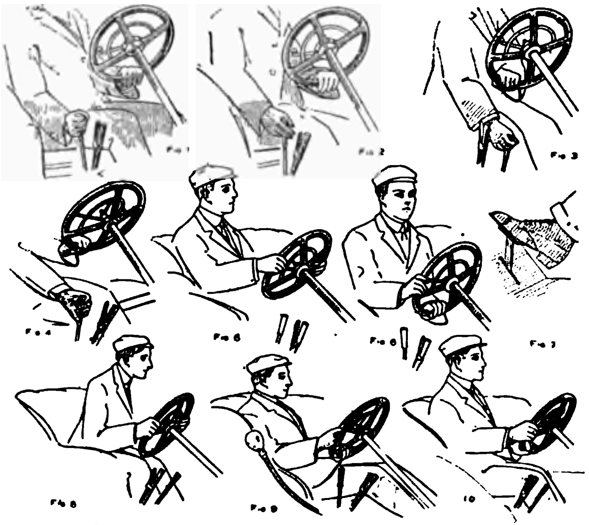


Fig. 3—Proper Way to Stand to Start a Car



1—Pierce Grip a Bad Method; 2—Correct Hold for Forward Movement; 3—Finish of Forward Movement; 4—Alternative Grip Suitable for Many Gears; 5—Awkward Hold of Wheel; 6—Proper and Comfortable Hold; 7—Wrong Foot Position; 8—Nervous, Uncomfortable Position; 9—Careless, Lounging Position; 10—A Correct "Seat"

Fig. 5—Correct and Incorrect Positions in Driving

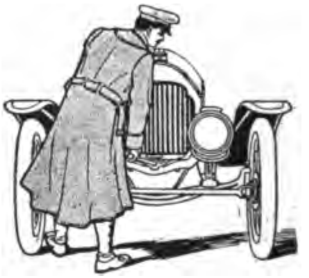


Fig. 4—Improper Way to Stand

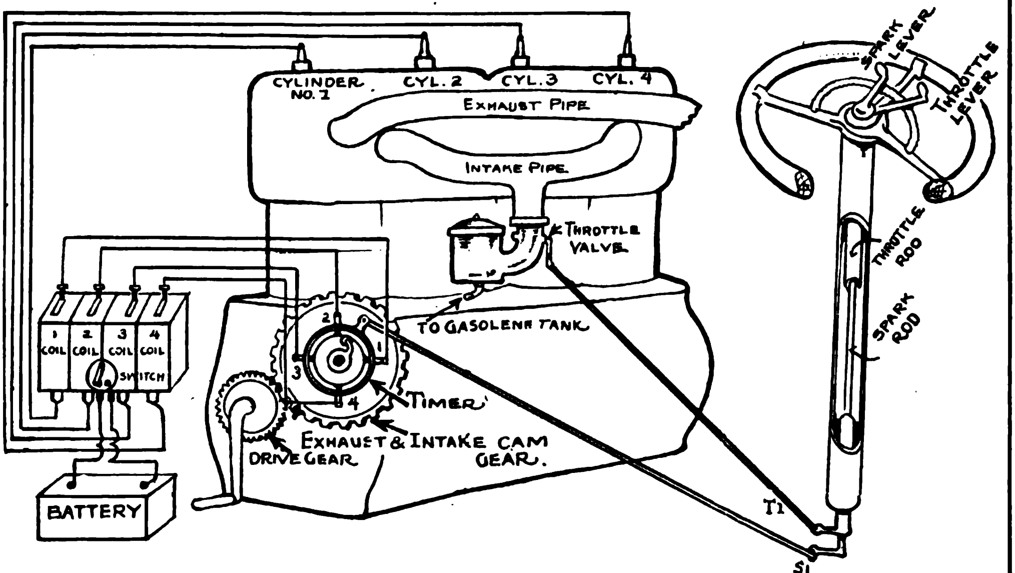


Fig. 6—Illustrating the Method for Controlling the Speed of an Engine

CHART No. 131

STOPPING A CAR.

Stopping a Car on an Up Grade and Starting Again Require Skill, for the brakes must be withdrawn and the clutch let in at the same instant with one movement.

Until This Skill Comes Through Experience, the best thing to do when this is necessary is to block the wheels with stones or pieces of wood.

The Beginner's Idea of Stopping is to throw off the power and put on the brakes.

While This Will, of Course, Produce the Desired Effect, it is not correct, for it would rack the car and damage the tires.

The Car Is Heavy, and when moving tends to keep on moving, so that its stops must be gradual.

To Stop, first retard the spark and throttle the mixture, to keep the enigne from racing when relived of the load.

Make Up Your Mind Just Where the Car Is to Stop, and throw out the clutch a sufficient distance ahead for the car to come to a stand of its own accord.

Brakes Should Be Applied Suddenly only when it is absolutely necessary, for they are powerful enough to lock the wheels and make the car slide.

Sliding Grinds the Tires, and means their quick ruin.

The Flashy Driver, who brings his car to a sudden stop, is laying up a big repair bill.

When the Brakes Are to Be Applied, pressure should be brought on them gently at first, being increased gradually so that the car slows down gently.

It Is Easy to Learn to Estimate the distance at which a car will come to a stop when the clutch is thrown out, so that the coasting of the car may be utilized in slowing and stopping it.

When Stopping, get into the habit of retarding the spark and throttling the mixture first, to prevent the engine from racing.

If Only a Short Stop Is to Be Made, the motor may be kept running at its slowest speed, but if the stop is to be for some time, cut off the ignition and stop the engine.

STOPPING AN ENGINE.

In Stopping a Four Cylinder Engine, open the throttle wide before switching off the current, as this will fill the cylinders with a fresh charge, and the engine may often be started by switching on the ignition and moving the spark lever from one end of its arc to the other.

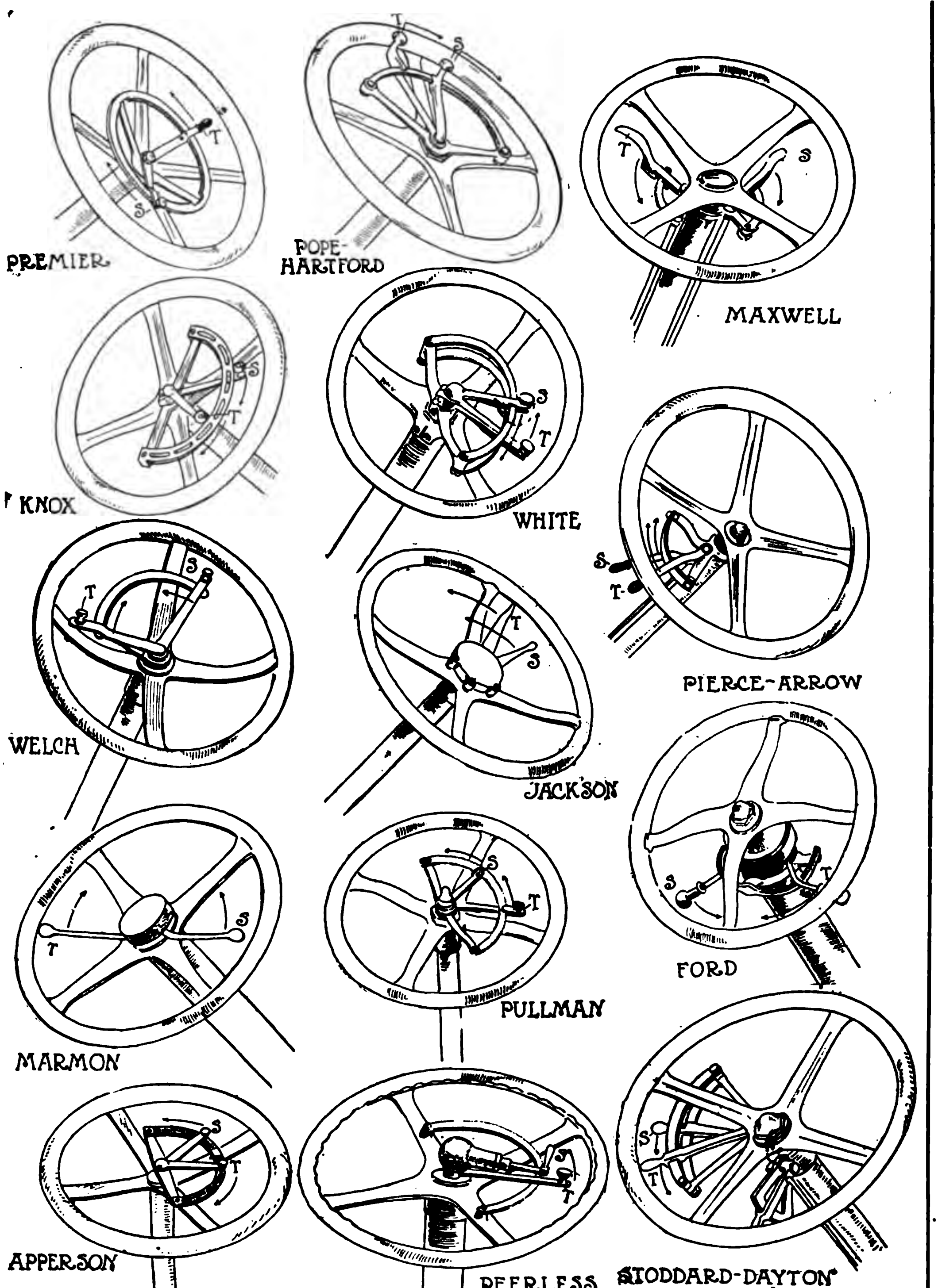
Never Leave the Car Alone With the Engine Running, for a small boy might experiment with the levers and start the car.

In Leaving the Car, always put on the emergency brake, to keep it from accidental moving.

In Starting the Engine After a Stop, be sure that the control lever is in the neutral position, as otherwise the turning of the starting crank will move the car, and the man cranking might be run over.

In Reversing, never throw the clutch until the car has come to a dead stop.

If the Clutch Is Thrown In Before the Car Has Come to a Stop, the teeth may be torn out of the gears, or if not, the car will start backward with such a jerk that the passengers may be thrown out.



S—Indicates the Spark Lever and connects to timer or (contact box of magneto—see chart 88A). It is used to "advance" and "retard" the time of ignition. See chart 131, Fig 6.

T—Indicates the Throttle Lever and connects with the throttle valve on carburetor (See Fig. 6, Chart 131). Opening the throttle admits more gas to the cylinders, consequently speeds up the engine. The spark lever is also advanced with the throttle lever.

The Arrow Point indicates the direction to move the above levers to **Advance.**

Spark and Throttle Control on Various Cars

CHART No. 132

POINTS TO REMEMBER IN STARTING ENGINE.

Fig. 1, Chart 131, Illustrates Method of Holding Crank in Starting. If the crank is grasped as shown in illustration, Fig. 2, it is wrong, if the motor "back fires" the position of the thumb will prevent letting go.

Figs. 2, 3 and 4 Show the Proper and Improper Way of Standing when cranking.

Most Motors Turn Clockwise, that is, from left to right.

Then in Starting, the Ordinary Driver, who has just "picked up" driving, grabs the crank with the right hand and pulls on it until the top is reached, then pushes it over the center and the motor either starts or it does not. In the latter case he continues to pull it around. This method, whether right or wrong, may possibly work on a small engine, but wait until this plan is tried upon a large motor.

With Left-Hand Starting, as the turn of the crank is away from the center of the car, its movement may be counted upon to give the driver more room in which to stand.

Instead of the Last and Hardest Part of the Cranking Being in the Nature of a Push with the arms stiffened, with the left-hand starting, it is more of a pull with the elbow flexed and therefore free.

If the Engine Back-Fires it is easier to let go of the spinning crank, because it is exerting a pull on the hand, not a push as before.

The Advantages of Left-Hand Starting is less danger to the operator's arm, easier balance of the body and less work.

CONTROL OF THE SPEED.

The Spark Lever on the steering wheel connects with the rod "SI" **at the bottom of the steering arrangement; this in turn connects with** the timer, if a high tension coil system of ignition, (See Fig. 6, Chart 131), or the "contact breaker" on the magneto if magneto ignition. (See Chart 88A.)

When the Spark Lever Is Moved, on the top of steering wheel, it in turn moves the timing device or commutator or contact breaker; either advancing is so that it will make contact EARLY; or retarding it so that it will make contact LATE.

It Is Possible to Often Times govern the speed of an automobile when a small amount of gas is being used, by advancing or retarding the spark. In "advancing," the speed is increased and in "retarding," the speed is decreased.

The Throttle Lever connecting to the throttle on the carburetor.

By Opening the Throttle Lever more gas is permitted to enter the cylinder and consequently more speed.

To Increase the Speed of an Engine, the usual procedure is to open throttle and as the throttle is advanced, gradually advance the spark.

To Decrease Speed, retard spark and throttle. (See Chart 40A.)

THROTTLE AND SPARK LEVERS.

Chart 132 Illustrates 14 Types of Steering Devices with their various arrangements of spark and throttle control.

The Letter "S" means spark lever.

The Arrow indicates the direction of movement for advancing speed.

The Apperson shows a step from the conventional in that the throttle and spark move over a one-quarter circle, the throttle being pulled down to open and the spark pushed forward to advance, so that the higher the speeds the farther are these controls apart.

On the White a reversal of this arrangement is used, the throttle being pushed forward and the spark backwards for advancement.

On the Knox and Pope-Hartford both are pulled towards the driver to advance.

The Knox Is Different from the ordinary in that the throttle is the shorter control lever and on the inside of the quadrant. The reason for this is that the accelerator is used when driving the car so that the hand control is practically eliminated.

The Welch belongs to this class of control, but in it the spark and throttle move in opposite directions and approach each other in the advance position. This brings both under the control of one hand at high speeds.

SPARK AND THROTTLE ON OPPOSITE SIDES.

There Are Many Makers who place the controls on opposite sides, the spark on one side and the throttle opposite.

In This Class Can Be Noted the Marmon, Mitchell, Reo, Premier, Maxwell and Ford. On these it is general to place the throttle on the right side, excepting in the case of Marmon, in which the throttle control is long so that is can be operated by the thumb of the left hand without taking the fingers off the steering wheel.

The Franklin has but a single control for the throttle, the spark being under the governor control.

Two Cars Place Both Throttle and Spark Beneath the Steering Wheel at the Left Side; these are Pierce-Arrow and Stoddard-Dayton. The advantages claimed by exponents of these cars is that it is possible to control both by the fingers of the left hand without releasing the hand from the steering wheel, in which case the right hand is left free to control the change-speed lever.

Exponents of All High-Speed Work Claim it is not necessary to need the right hand for this work and in reply it might be stated that the gearset is put in for a purpose and why not use it, and by so doing keep the motor running at a more uniform speed?

FOOT PEDALS.

A Standard Form of Brake and Clutch Pedal is shown in Chart 130, Fig. 2.

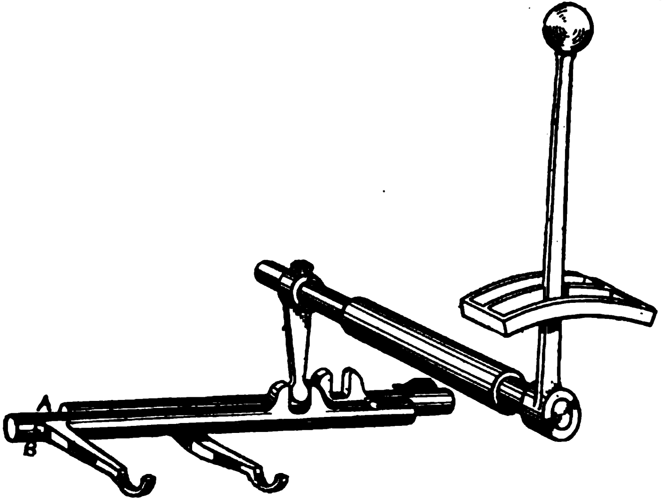
B—Foot Brake or running brake.

C—Clutch Lever which throws out the clutch, thereby leaving the engine FREE from the drive to rear axle.

A—Is the Throttle operated by foot; it is called the "Accelerator," which simply means an auxiliary throttle.

In Figure 1, Chart 130, we illustrate a clutch pedal, M, B is fly wheel on engine, BI the cone clutch, A spring tension against this clutch forcing it into the fly wheel shaft, H is engine shaft.

For Example. Suppose engine was running, if the driver had his foot on pedal "M," the car would not move, but if his foot was OFF, the fly wheel would turn clutch and clutch would turn shaft of transmission and if transmission gears WERE IN MESH the gears would turn shaft to rear axle.



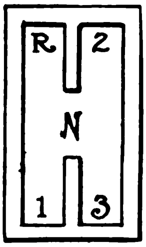


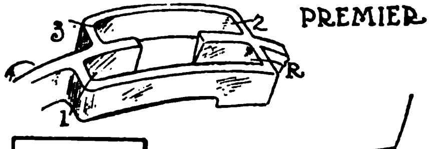
Fig. 2—Shows Arrangement of "Selector" with Positions for Change of Speed Marked Thereon.

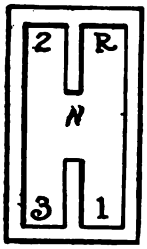
Note the lever in Fig. 1 now stands in "N" or neutral position.

In order to get this change of speed clearer see Chart 23.

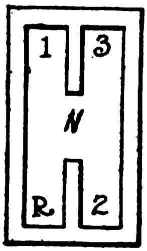
Fig. 1 — The One Lever for Operating the Change of Gears in the Selective Type of Transmission. This Lever Works Sideways as Well as Endways

This style of lever is called the "selector" principle of change-speed gear lever. The long, vertical hand lever can be moved both endways and sideways in the selector. The transverse shaft carries an arm which can engage one of a series of slotted lugs on the "selector" bars, which have forked extensions which engage the respective gear wheel sleeves. Only one sleeve at a time can be actuated; the non-operative selector bar is held in position by a spring catch, so that its gear sleeve is kept out of mesh.

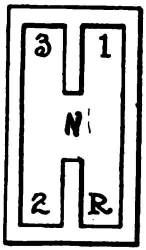




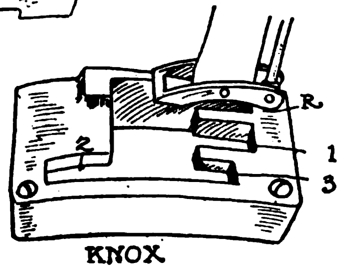
No. 3



No. 4

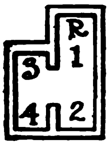


No. 5

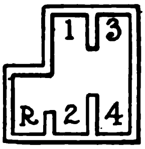


The Above "Selectors" are all THREE Speed Selectors

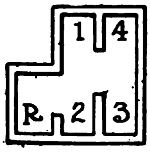
The Selectors Below are Four Speed Selectors



No. 5



No. 6



No 7

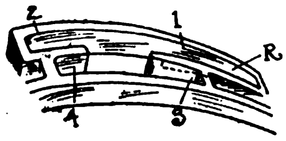


Fig. 8 — The Pierce-Arrow TWO-Slot, but Four-Speed Selector

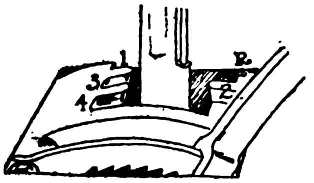


Fig. 9—Winton

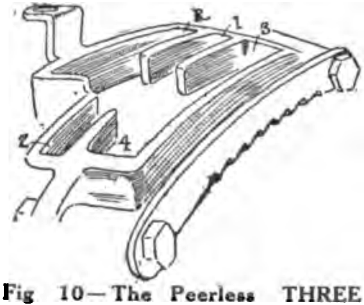
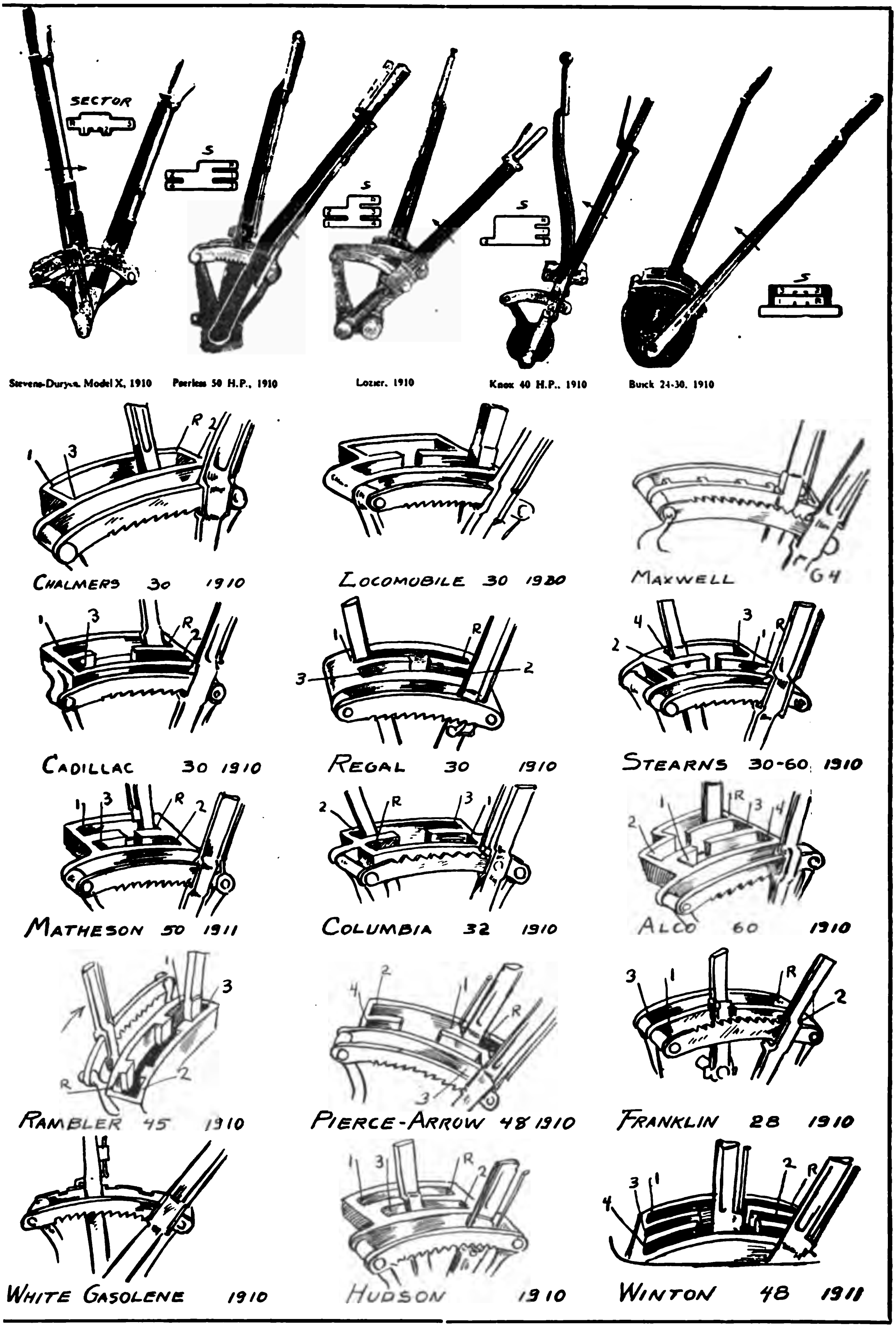


Fig 10—The Peerless THREE Slot, Four Speed Selector

Selectors



Arrangement of Selectors, Three and Four Speed, on Various Cars

CHART No. 134

If the Lever Which Shifts the Gears Is in "Neutral" Position, then there are no gears in mesh and the engine may run without moving car and without the necessity of holding down the clutch pedal.

CHANGE GEAR LEVERS AND SELECTORS.

We Deal With the Selector Type of Lever, which shifts the various gears in this description.

In Order to Thoroughly Understand the Principle of this lever see Fig. 1, Chart 133; you will observe that the lever moves sideways as well as forward and backward.

An Analysis of the different arrangements of positions of the change-speed lever for a gearset having three forward variations is as follows:

Selector Shown in Fig. 2, Chart 133, is a very simple arrangement, in that the second and high speed (2 and 3) are in the same slot, making it an easy matter to drop from high to second in climbing a hill, or if desired the car can be started on second, which makes an easy shift to high.

The Position Shown in the selector in Fig. 1, Chart 133, the lever is in "neutral" position, meaning a position where there are no gears in mesh, and in this position the engine can run without the car moving.

If We Wish to Start the Car in Motion (engine supposed to be running) we place the foot on the clutch pedal "M" (Chart 130), releasing the clutch from fly wheel, and while holding clutch out we take the lever, which is now in neutral and shove it sidewise, in toward the car, and then push it forward into first speed (1—Fig. 2), which is the lowest speed.

It Is Easier to Start on a Low Speed.

After Car Is in Motion bring lever back to neutral position "N," push lever out and pull it backward into second speed (2), when car is well in motion it is thrown forward into third speed (3), which is the highest speed (unless car has four speeds).

To Place the Gears on Reverse, place lever in neutral position, then back into "R" (Fig. 2).

THERE ARE SEVERAL TYPES OF SELECTORS.

Different Manufacturers Use Different Selectors as shown in Chart 133 and Chart 134.

Some Transmissions Have three changes of gears and other four changes of gears or speeds, together with a reverse gear.

The Three Changes of Gears is the type of transmission used on the small and medium size cars. Only a few of the large cars use four changes of gears.

In a Selective Control it is best to have those speeds in one slot as shown in Fig. 2, Chart 133, which are most frequently used and which must be changed in ascending hills or other places where good driving is required.

A Few of the Followers of This Style of (No. 2) "selector" are:

Stoddard, Stearns, Mitchell, Jackson, Overland, Regal, Speedwell, Kissel, Courier, Hudson, Thomas model M, Pierce-Racine, Pullman, Cadillac, Marmon, Apperson small model, Matheson six, E-M-F, Elmore, Ricketts; and in addition to these must be added Auburn, Velie, Reo and Chalmers, which do not use an H quadrant, but have the change-speed lever in the same position for these speeds.

The Second Most Popular Design of H Quadrant is Number One, type reversed. (See No. 3, Chart 133.) Second and high speeds are in the inside slot, reverse and low in the outside slot.

The Advantages of this type are practically the same as those in Number One and undoubtedly this has the additional advantage that having second and third speeds in the innner slot is a greater convenience, because the lever is closer to the driver and more readily handled. Adherents of this No. 3 type are Premier, Haynes, Buick, Pope-Hartford, Fal-car and Black Crow.

OTHER TYPES OF POSITIONS.

But There Are More Types of Quadrant positions. In type No. 4, used on Inter-State, Rambler and National cars, the low speed is forward (1), reverse in and back (R), second speed out and back (2), and high and out and forward (3).

An Out-of-the-Ordinary Arrangement is No. 5, used on the Corbin and Columbia, which is simply the reverse of that used on the Inter-State and Rambler, and in which third or high is inside and forward, second inside and back, low outside and forward, reverse outside and back.

On the Franklin low and second are inside, back, and inside forward respectively; and reverse outside forward, and outside back for high.

The Franklin is the only example in which reverse and third are paired in the outside position, or in fact the only one in which reverse and high are paired in any position.

FOUR-SPEED TYPE OF SELECTORS.

On Four-Speed Selectors the lack of regularity is as great as on three speed types. A few examples of quadrants (Chart 133) show this diversity.

It Is Customary where there are four forward speeds to use a three-slot quadrant, but on the Pierce-Arrow and Locomobile two-slot types are used. (Fig. 8.)

In Fig. 10 the Peerless type shows a three-slot, four-speed selector.

On the Pierce-Arrow the inside slot is extra long with reverse at the front, low speed about the middle, and second speed at the rear—an arrangement which leaves third and fourth speeds in the outside slot.

In the Locomobile this order is reversed, having third and fourth speeds inside, and reverse, low and second in the long outside slot.

All of the Other Cars using four-speed sets have three slots.

The Peerless and Appersons Are Much Alike, the reverse being a separate slot next to the car body, leaving first and second in the intermediate, and third and fourth in the outside slot.

The Only Difference in these controls is that in Peerless (Fig. 10) reverse is forward, whereas in Apperson (Fig. 7) it is back.

Other Type of "Selectors" is shown in Chart 134.

INSTRUCTION No. 28

CARE OF A CAR:—Periodical Attention to a Car. General Pointers in Driving.

CARE OF A CAR.

PERIODICAL ATTENTION TO THE CARE OF A CAR.

To Give Good Service an automobile requires careful watching, not only while running, but between trips.

There Should Be a System of Examination that will cover carefully all parts that are likely to get out of order, and this should be gone through every time that the car is used.

In Addition, attention at regular intervals should be given to the parts that are less likely to give trouble, but on which an eye should be kept nevertheless.

LOOK TO THE FOLLOWING DAILY:

(1) **Fill Gasoline** tank.

The funnel that is used for gasoline should never be used for water, lubricating oil, or anything but gasoline.

(2) **Fill Water** tank.

(3) **"Tickle" or Prime** the carburetor, to make sure that the float is free, and the gasoline flowing.

At the same time inspect the connections of the gasoline line for leaks and loose joints.

(4) **Test the Batteries,** and see that the storage cells are properly filled with electrolyte.

(5) **See That the Vibrators** are working properly.

(6) **Fill** the lubricator.

The Opening of This is usually so small that a funnel is necessary to keep the oil from running over.

Make Sure that the oil has not drained out of the crank case.

Beginning at the Front of the Car and working to the rear, screw the grease cups down slightly, filling those that are nearly empty.

While Doing This, watch for loose nuts, and for parts that may be out of place, loose or in need of attention.

Be Particular to Keep the Steering Mechanism in Good Condition, and plentifully lubricated.

(7) **Test** the brakes.

(8) **Pump Up the Tires,** and keep them pumped up.

(9) **See That the Tools,** supplies and extra parts are on board.

When Accustomed to It, this system will not require much time, and it will result in the condition of the car being under observation at all times.

The Above Points Should Be Observed for Every Run, but others should be attended to from time to time.

LOOK TO THE FOLLOWING ABOUT EVERY 500 OR 1000 MILES.

When the Car Has Run 500 to 1,000 Miles, the crankcase should be drained and washed out with kerosene.

Grit and Dirt will work in and thicken the oil, and must be removed.

Every 1,000 of 1,500 Miles, drain and wash the change speed gear case.

Constant Use will grind particles of steel from the gears, and cause rapid wear.

This Oil, as well as that drained from the crankcase, may be filtered and used again; the oil does not deteriorate, it is the grit and dirt in it that is harmful.

The Crank Case should be filled with oil so that at bottom dead center the connecting rod end dips into it about an inch.

Fill the Gear Case so that the smallest gear dips into the oils about a half inch.

If the Differential Runs in Oil, wash it and renew the oil two or three times a season; if it is packed with grease, one filling a season is sufficient.

Wash Out the Bevel Gear Case every 1,000 or 1,500 miles, refilling it with heavy oil.

LOOK TO THIS ABOUT EVERY 2,000 MILES.

Every 2,000 Miles, take off the wheels, clean and examine their bearings, and repack with the lubricant, being careful to readjust them correctly.

Squirt a Few Drops of Kerosene Into Each of the Cylinders occasionally, working it around by cranking the engine, for this will keep the piston rings loose and free from gummy deposits.

Do Not Use Gasoline for Washing Metal, for it cleans down to the metal, leaving a rough surface; use kerosene which gives better results.

WASHING THE CAR.

For Washing the Car, use only clear water. (Warm water, if possible, in winter.)

If Soap Is Used, get a good carriage soap that has no acid in it. If it contains acid it will take off the varnish.

Mud Should Not Be Rubbed Off, for the varnish would be scratched and pulled

Let the Water Run Gently Out of the Hose, using no nozzle, and flow over the mud, so that it washes away slowly—spray the water.

The Full Force of the Water May Be Used to Remove Mud from under side of fenders; but not from any varnished part.

If a Hose Cannot Be Used, pour the water on, so that the mud is carried away.

Dry Mud Is More Difficult to Remove, but if the varnish is to be kept bright, use only the above method, and take time to it.

When the Body Is Clean, go over it with a soft sponge, using plenty of water, and dry it with soft, clean chamois skin or wash leather.

CLEANING UPHOLSTERING.

Keep Water Away From the Upholstery, for it will enter the folds and rot it.

If leather upholstery is dirty, it may be washed with soap and water, and afterwards polished, if necessary, with a leather reviver.

Wipe the Leather With a Slightly Oily Cloth, afterward rubbing it dry.

THE BRASS WORK.

When Going Out for a Run in Damp or Rainy Weather, it saves labor to give the brass work a light coat of vaseline to protect it from tarnishing, and put rubber bags over the lamps.

When There Is Little Time to Give to Cleaning the Brass Work, paint it with black or colored enamel, which looks better than uncleaned brass.

KEEP LIGHTS IN WORKING ORDER.

Gas Tips often become clogged and are thrown away.

By Inserting a Small Wire in the hole in the tip it will frequently render the tip serviceable again. (See Chart 120.)

SPONGE OFF YOUR BONNET.

Particular Attention Should Be Given to the Bonnet after the car has been run in a heavy rain, in as much as after a long run the bonnet becomes fairly hot, and if raindrops are left dry upon it they will stain much more than upon the body. The car should be washed down at once, or if this is not possible, the bonnet should be sponged off upon returning and wiped dry.

GENERAL POINTERS IN DRIVING AND CARE OF THE CAR.

The Driver Must Keep His Eyes and Ears Open, watching the other occupants of the road as well as the running of the car.

The Ear Is the Best Judge of the Running of the Engine, as it shows any defect by a change in its steady throb.

With Practice It Becomes Easy to Recognize a New Noise, and the cause should be located and remedied at once.

A Squeak or Rattle that comes at regular intervals may be located in one of the revolving parts, and if irregular, it comes from something that is not revolving; the springs, brakes, or similar part.

Irregular Running of the Engine may not be serious, but rather the result of a rough road or loose ignition connections.

Knocks or Pounds Should Be Located at Once, for they may lead to a serious breakdown.

LUBRICATION IS IMPORTANT.

With Engines Using the Gravity System of Lubrication, it is necessary to turn on the oil when starting, and to turn it off when stopping.

Be Careful to Turn It On, for it takes only a little running without oil to cut the cylinder walls and piston rings.

Be Careful to Turn it Off, for the oil keeps flowing, whether or not the engine is running, and if not prevented the tank will be emptied and the crank case flooded.

Excessive Oil in the crank case means fouled spark points, and should never be permitted.

DON'T FAIL TO STUDY CHART 169 (RULES OF THE ROAD).

In Running, keep to the right, and in meeting another vehicle turn farther over to the right, so that it will have room to pass.

In Passing a Vehicle going in the same direction, turn out so that it is on the right, and do not swing back to the right side of the road too close in front of it.

The Other Vehicle May Speed Up as You Pass, and be closer than you realize.

Get Thoroughly Familiar With the Different Speeds, so that there will always be time to stop when necessary.

Keep Your Eye on the People Alongside of the Road, for they may start to cross without warning.

Children Are Liable to Run Out of a Gate, or across the road, when they are least expected.

Cross Roads and Cross Streets Must Be Watched, for vehicles or people may come along them.

It Is Dangerous to Run Over a Dog, for the steering mechanism may be broken, or the car upset.

It Is Far Safer to Slow Down when one is barking in front of the car than to try to push it out of the way.

Blow the Horn When Approaching a Turn in the Road, for another car may be coming.

Do Not Run on the Low Speeds if it is possible to run on the high, for it means more revolutions of the engine, and consequently greater chance of its overheating.

SAVE THE TIRES.

If a Tire Blows Out, do not jam on the brakes—cut off the power and let the car coast to a stop.

Jamming on the Brakes Might Cause a Skid, and that would fatally ruin the tire.

In Crossing Loose or Broken Stone, as on a new road, do not drive the car over, but get up speed and as the car strikes the stones throw out the clutch so that the car will coast.

If the Car Has Not Enough Momentum to Cross, let it go as far as possible before again throwing in the clutch.

Driving the Car Across Sharp Stones forces the wheels to press as far as possible against them, while if the car moves without being driven, the tires roll over the stones, and are not so liable to injury.

TIRES ARE SAVED BY CAREFUL HANDLING.

Jamming on the Brakes Grinds the Tires, and wears them as nothing else does.

Letting In the Clutch Quickly so that the wheels spin before taking hold of the road, gives the same effect.

Tires That Are Not Sufficiently Inflated will rim cut, and are more liable to puncture than if blown up hard.

Oil Rots Rubber, therefore, keep the tires clear from it.

If They Get Oily, wipe them with a cloth soaked with gasoline.

If the Car Is to Be Idle for a week or more, jack up the wheels to take the weight from the tires—it will be better for them.

Rusty Rims cause rim cuts—therefore keep them smooth.

When Rims Rust, scrape them or rub with emery cloth, and give them a coat of shellac or lead paint to prevent them from rusting again.

Wipe the Mud From Tires with a damp cloth, rather than flush it off with a hose, to prevent the water soaking in between the rim and the bead.

In Applying New Tires, put them on the rear wheels, moving the half-worn one to the front wheels—this will give them a longer life.

In Applying a Single New Tire, put it on the right hand rear wheel, as this is the one that has the hardest work, and needs to be stronger than others.

DON'T REPAIR AN INNER TUBE ON THE ROAD.

An Extra Inner Tube Should Always Be Carried, ready to insert in case of a puncture. Take out the old tube and put in the extra, then have the damaged one vulcanized. It does not pay to cement a patch on a tube, have it vulcanized.

SKIDDING IS DANGEROUS AS WELL AS EXPENSIVE.

Side Slipping, or SKIDDING, is one of the dangers of driving an automobile, and must be guarded against.

Skidding Occurs When the Wheels Slip on the Ground because they are revolving faster or slower than they should be for the speed of the car.

Jamming On the Brakes so that the wheels are locked will tend to make the car skid, for pebbles or small stones in the road will act as ball bearings over which the wheels slide.

A Muddy Road Will Act in the Same Way, for the tires cannot get sufficient grip to hold the car to its forward movement.

Going Around a Turn at High Speed may cause a skid, for the momentum of the car will tend to keep it going straight ahead, and the grip of the wheels on the road may not be sufficient to hold it to the turn.

When Making a Turn, the conditions are such that the brakes should not be applied—always make a turn at the slowest speed.

Take Turns With as Wide a Curve as Possible, for the wider the turns is, the less tendency there will be to skid.

When a Road Is Crowned—that is, higher in the center than at the gutters—keep to the inside gutter in making a turn.

This Will Give the Same Effect as the Banking of the Turns of a race track, and the turn may be made at higher speed than if the road is flat.

If the Car Skids, turn the steering wheel in the direction in which the car is skidding, which will give it a chance to straighten out.

The Clutch, of Course, must be thrown out at once—and do not throw on the brakes.

A FEW WORDS ABOUT GASOLINE.

GASOLINE MUST BE HANDLED WITH CARE AND COMMON SENSE.

It Is Dangerous if handled carelessly, but need not be so if the operator uses judgment.

Gasoline Vaporizes Easily, and as the vapor is heavier than air, it sinks to the ground.

When Filling the Tank, be sure that there are no open lights near, or a fire.

If the Tank Is to Be Filled at Night, put out the lamps, and use a pocket electric flash lamp instead—this is inexpensive, and may be purchased at any hardware store.

Have a Funnel for gasoline, and do not use it for anything else.

In Case of Fire, do not try to put it out with water, for the burning gasoline will float and spread the fire.

Always Keep a Pail or Two of Sand in the shop, and smother the flames with it.

In Case of Fire, the first thing to do, if it is possible, is to turn off the supply cock from the tank to the carburetor, and then push the car away from the blazing gasoline on the ground.

Do Not Let a Pool of Gasoline Drip From the Carburetor when priming it, for a chance short circuit may give a spark that will set it on fire.

KNOW YOUR CAR.

Remember that in the Care and Operation of a Motor Car, Much Must Be Left to the Judgment of the Operator, who should study the construction of his car and thoroughly acquaint himself with its mechanism, the functions of its various parts and the why of everything connected with it.

Learn the Speed at Which the Car Will Take a Turn on mud or wet asphalt, without skidding or side-slipping, and never exceed it.

Learn the Grade of a Hill That the Car Will Climb Easily, and on steeper grades do not wait for the engine to labor before changing the speed.

Learn the Distance That the Car Will Travel Before Refilling the Tanks—not from the catalogue, but from your own experience, so that hold-up on the road for supplies may be prevented.

Learn the Turn that it will make for every position of the steering wheel, and always make the broadest turns that the width of the road will permit.

A Sharp Turn is more likely to strain and injure the tires, running gear and steering mechanism, than a broad turn, and if the car is speeding, more likely to cause an upset.

Learn the Rapidity With Which the Car Will Pick Up Speed after a slow-down, as it will help when running through traffic, or when it is necessary to dodge another vehicle.

It Is Important to Learn the Shortest Distance in Which the Car Can Be Stopped for its different speeds, and the exact amount that it slows down for each application of the brakes.

Learn to Use the Brakes so that the motion becomes automatic, and can be done without wasting time thinking about it. Learn to judge distances, and the speeds at which the car travels; ability to estimate speeds may prevent arrest.

Learn to Recognize the Noises of the Engine when it is running smoothly; the buzz of the vibrators, the click of the valves, the hum of the timing, pump and magneto gears, the puff of the exhaust, so that unhealthy noises may be easily recognized.

Learn the Feel of the Compression, as shown by cranking the engine, so that leaks may be detected.

Learn the Effort Required to Push the Car on a Smooth Floor by Hand, so that a binding brake or a tight bearing may be felt.

In Short, Get in Tune With Your Car—be part of it—make it part of you; that is, if you want to get good service from it, and save on the repair bills.

SOMETHING TO REMEMBER.

The Flashy Driver, who makes quick turns and sudden stops, attracts attention, but ruins his car.

The More Smoothly a Car Is Operated, the longer it will last, and the less often it will get out of order.

Driving Is Not a Thing to Worry About, but to be taken easily.

Easy Turns, gentle stops, the running of the engine as slowly as possible for the speed desired, proper adjustments, and constant care, mean long life to the car, and freedom from trouble.

When the Engine Is Not Acting Right, do not rush in and re-adjust the vibrators or carburetor without first being sure that the trouble has been correctly located.

Throwing the Carburetor Out of Adjustment on a guess makes it all the harder to get going again, for its readjustment must be added to the trouble already present.

An Automobile Is Not Difficult to Handle, but neither is it so simple that brain work is not necessary.

Get All of the Facts possible before doing anything to the mechanism—the noise that the engine made in stopping, the way it stopped, the reasons for the unnatural noises, and the bolts from which nuts may have dropped off.

An Automobile Is Constantly In a State of Severe Vibration, and almost any part is liable to work loose when least expected.

Some Accessories are convenient, and others are nuisances.

Do Not Load the Dash Up With Devices that are not of practical use, for they only add to the parts that must be watched and taken care of.

Provide the Car With a Good Horn, and use it well when necessary, but never needlessly.

INSTRUCTION No. 29

TROUBLES AND REMEDIES:—Various Sources of Trouble. Miscellaneous Troubles.

Experience and Practice Are the Best Instructors in Keeping a Car Running, and give the operator the ability to recognize the seat of the trouble from the action of the engine in failing to deliver full power, or in the manner in which it stops.

***The Troubles That May Hold Up an Automobile** may come from any one of several causes, and these will first be explained, followed by their effect on the engine.

IGNITION TROUBLES—MOST FREQUENT.

The Most Frequent Trouble Comes From Ignition, and it is usually the most difficult to locate.

All of the Parts of the Ignition System May Be Counted on to Go Wrong, and should therefore be carefully watched.

LOOSE CONNECTIONS.

The Constant Vibration of the Car has a strong tendency to loosen nuts, and those that hold the connections in place should always be firm.

If a Connection Is Loose, sometimes the current may flow and sometimes it may not, according to whether the vibration brings the wires together.

All Connections Should Be Firm, the binding post nuts being run down with pliers.

It Is Difficult to Hold a Bundle of Fine Wires, such as compose a secondary cable, firmly under a nut, and it therefore is advisable to solder a brass or copper terminal to the end.

This Gives the Nut Something Firm to bear against.

Corroded Terminals and Connections present resistance, and corrosion should therefore be prevented.

Rub the Terminals Bright, and after the connection has been made smear it over with vaseline or paraffine.

DRY CELL BATTERY TROUBLES.

When a Battery Is Exhausted, or nearly so, it will not produce a spark sufficiently hot to ignite the charge, and the engine will then miss an explosion.

The Length of Time That a Battery Should Last, or the mileage that it should make, is shown by experience, and when it runs down in much less time, there is evidence that it is short circuited.

As a Short Circuit May Occur at Any Time, the battery may be suspected for any failure of the engine to deliver full power.

If a New Battery Is Short-Circuited, it will cease to deliver current, but this may not be for the same reason as when it is exhausted after long use.

***For a complete Digest of all Troubles; how to find the Cause and how to Remedy all Troubles, see index—also see index for "Digest of Troubles" and "Questions Asked and Answered," and turn to these pages and read carefully.**

When a Battery Is Delivering Current, a gas (hydrogen) is produced in it, and while this forms around both poles, most of it forms around the carbon.

When the Current Is Delivered as Required, as is the case when there is no trouble, the gas rises and passes out of the vent in the top of the cell.

A Short Circuit Will Produce so much of the gas that it will entirely cover the carbon, and as it is an insulator it will prevent the current from flowing.

A Cell in This Condition is said to be POLARIZED.

If Left Standing With the Circuit Open, the gas will gradually pass off, so that the liquid or dampness in the cell can get at the carbon again, when the cell is said to have RECUPERATED, or able to deliver current again.

Before Using the Circuit Again, however, the short circuit, or cause for the cell being polarized, should be located and removed, or the cell will again be polarized.

The Gas May Be Driven From a Polarized Cell by passing a current from another equal cell or battery through it in the reverse direction; that is, connecting the two so that the current flows in at the positive pole and out by the zinc or negative pole.

If a Battery Is Exhausted Through Use, it will pick up a little if permitted to stand idle, and an automobile may often be brought home if the engine is run slowly, and stopped frequently to give the battery a chance to recuperate.

The Extra Battery with which the car should be provided is for use in such an emergency.

If Both Sets Are Exhausted, they may be connected together so that they will deliver current for considerably more running. See Chart 65, Fig. 3.

If as Is Ususally the Case, each set is connected in series, the two may be connected together in parallel.

This Is Done by Connecting the Carbon Pole of one set to the carbon pole of the other set, and connecting the zinc poles in the same manner.

Dry Cells Should Be Tested With a Battery Tester ammeter, and if they show 6 amperes or less per cell, they are exhausted.

Further Use May Injure them fatally.

It Frequently Happens that mistakes are made in connecting together cells or batteries, so that the current from one flows in the opposite direction to that with which it is connected.

One Will Thus Neutralize the Other, and the result will be that the current will be weakened by losing the effect of both.

This Should Be Watched for and corrected.

Storage Cells Should Be Kept Filled With Electrolyte to the proper point, for if it leaks away the cell will not be able to deliver its share of the current.

COIL TROUBLE.

There Is Always a Small Spark between the contact points of the vibrator of the coil, and in time this will burn the platinum so that it does not make good contact. (See Chart 74.)

The Points in Such a Case should be smoothed with a very fine flat file, for the better the contact the smaller the spark will be.

When Worn Out, the points may be renewed by soldering short lengths of platinum wire to the vibrator blade and to the adjoining screw.

In the Latter, the wire is set into a hole drilled into its end, and the platinum in the hole should be removed by melting the solder that holds it in place.

This Is a Delicate Job and requires care.

The Insulation of the Coil and condenser often breaks down. so that a short circuit results, and the coil will not operate.

The Only Remedy for This is to return the coil to the makers.

It Is Not Advisable to Take the Coil Apart in any way beyond the removing of the parts of the vibrator, for the construction is exceedingly delicate, and any but expert handling may ruin it beyond repair.

WIRE OR CIRCUIT TROUBLES.

Aside From Loose and Corroded Connections, the circuit may give trouble from the breaking of a wire, or the wearing of the insulation.

Wires Will Break from the vibration, but solid wires break far more rapidly than cables made up of a number of strands of fine wire.

A Broken Wire At a Connection is easily seen, but when the break occurs inside of the insulation, it is difficult to locate, as it does not show on the outside.

The Best Test for it is to run a new wire.

If a broken wire is suspected, determine by testing whether it is a primary or secondary wire, and then run new wires, making one connection at a time.

As Each Connection Is Made, test for results.

It Is Poor Economy to Use Cheap Wire, for the best is none too good for the hard use to which it is put.

If a Wire Rubs against any part, especially against metal, the insulation will chafe, and eventually wear through.

This Will Expose the Wire, and probably cause a short circuit.

The Circuit Should Be Examined from time to time, to make sure that this is not occurring.

In Making Connections, it often happens that a single strand from a cable will not be secured, and being very fine, it may not be noticed.

It Will Cause a Short Circuit, and permit the current to leak if it comes in contact with other parts.

The Best Protection is to bind all connections with electric tape.

SPARK PLUG TROUBLES.

The Spark Plug Is a Frequent Cause for Trouble, for the heat will crack the porcelain insulation, or the carbon deposit will form on the insulation between the points, or between the points themselves, permitting the current to pass without jumping.

Plugs Should Be Made so that when the parts are screwed together the strain and pressure will not be against the insulation.

Mica Plugs are made of a great number of washers pressed together, and these frequently separate from the action of oil or heat, so that they do not insulate the shell of the plug from the wire passing through it.

A Cracked Porcelain will do the same thing in allowing the spark to pass inside the plug instead of between the points. (See Chart 46.)

The Carbon Deposit that fouls spark plugs and short-circuits them is the result of too rich mixture, or too much lubrication, and much of this difficulty may be prevented by correct adjustments.

The Inside End of the Insulation is frequently made with recesses, so that the carbon must cover a considerable surface before it can short-circuit the plug.

Under the Intense Heat the carbon bakes on hard, and must be scraped off or removed with a strong alkali.

The Inner Side of the Insulation should be as smooth as possible, so that the carbon cannot find a good surface to cling to.

When Scraping a Plug, be careful not to scratch it; brush it with an old tooth brush dipped in ammonia.

The Points Should Be About 1-32 of an Inch Apart; a frequent failure is caused by having the points so far apart that the current cannot jump.

A Current That Will Form a Good Spark Outside of the Cylinder may not spark at all when under compression, so that an outside spark does not indicate that it will pass under compression.

OTHER SIMPLE METHODS OF TESTING SPARKING PLUGS.

There Are Several Roundabout Ways of Testing a Set of Four or Six Sparking Plugs which involve an unnecessary expenditure of time and energy.

There Is No Need, for example, to take the plugs out or disconnect the cables.

There Is One Reason why plugs should not be unnecessarily disturbed, and that is, because once screwed home, the seatings will eventually become compression-tight, due to the thin film of oil under the washer which sets and form a kind of hermetic seal.

The Procedure does not differ very much, whether the ignition is by multiple coil, high-tension magneto, or single coil and distributor.

Take the Case of a multiple coil first; misfiring in one or two cylinders is occurring, due, perhaps, to a fouled plug.

The Principle of the Test is to cut out three cylinders simultaneously by lightly depressing three of the tremble blades, by which action those three coils are switched off, then, by the beat of the one cylinder, call it No. 1, left firing, it can at once be determined if it is missing or not; then three more cylinders can be cut out and No. 2 left in, and so on.

Some Coils Are Provided Either with a short-circuiting button for each section or a trigger which holds the trembler down at will—a very convenient arrangement.

The Test Can Be Made single-handed; but it helps considerably if an assistant can depress the tremblers, as then the observer can pay more attention to the beat of the engine.

Another Tip Is to Cut Three Small Slips Off a Visiting Card or an old envelope, and put one between each pair of platinum points, i. e., between trembler and contact screw.

This Makes an effective cut-out.

TIMER TROUBLES.

A Spark May Be Formed at the Timer for the same reason that a spark is formed in the make and break ignition system.

Timers Usually Run in Vaseline, which is an insulator and prevents the forming of this spark.

Because of the Presence of the Vaseline, the timer spring must be strong enough to bring the contacts together.

If the Spring Is Not Strong Enough to squeeze the grease from between contacts, the current cannot flow.

After Long Use the Contacts Will Wear, and when they are worn so that they are below the level of the insulating ring, good contact will not be possible.

New Contacts Should Be Set in the Ring, or the ring scraped or filed down so that the old ones project.

The Timer Should Be Attached to the Shaft so that its position cannot change.

If It Is Loose, It Will Throw the Engine Out of Time, and oil working in between it and its shaft will retard or prevent the flow of the current.

All of Its Parts and Its Connections Should Be as Firm as Possible, in order to present little resistance to the flow of the current.

SWITCH TROUBLES.

If the Parts of the Switch Work Loose, poor contact will result, and this is a difficult thing to locate.

The Blade Should Have Good Pressure against the contact points, and should be kept clean.

In Some Cars, the switch may be mounted on a metal part, such as the steering column, and in this case the wearing or misplacement of the insulation will cause a short circuit.

Trouble Comes So Rarely at the Switch that it is liable to be entirely forgotten; it takes only a minute to look it over to make sure of its condition.

MAGNETO TROUBLES.

The Chief Magneto Troubles are due to failure of the lubrication, the weakening of the magnetism of the field, and the breaking down of the insulation.

The Clearance Between the Armature and the pole pieces between which it revolves is very small, and when the bearings wear the armature will strike.

Therefore keep the armature bearings well oiled.

The Construction of a Magneto Is Delicate, and it requires expert handling.

If the Magnets Weaken, or if the insulation breaks down, it is better to return it to the maker than to take chances with it.

TANK TROUBLE.

The Tank of a Gravity Feed System is always provided with a small hole, usually drilled through the filling cap, by which air may enter to replace the gasoline as it is drawn off.

If This Hole Becomes Plugged With Dirt, the gasoline in flowing out will tend to create a vacuum, and the flow will stop.

This Trouble Is Difficult to Locate, for it has the symptoms of a lack of gasoline.

Opening the Cap to See Whether the Tank Is Empty Will Admit More Air, and the motor will again run, slowing down and stopping when the condition again exists.

Clearing the Vent Hole Removes the Trouble, which is spoken of as an AIR BOUND tank.

The Outlet Pipe Should Project slightly above the bottom of the tank, so that water and dirt may settle, and not be carried to the carburetor.

All of the Joints of the Gasoline Line Should Be Screwed, and well put together.

Gasoline Rots Rubber Rapidly, and should not be carried through a rubber hose, nor should joints be packed with rubber.

Shellac or Soap may be used when screwing joints together, as it helps to make them tight.

The Lowest Point of the Gasoline Line Is Usually at the Carburetor, and should have a cock or plug so that the system may be drained.

CARBURETOR TROUBLE.

Beside the Possibility of Getting Out of Adjustment, the greatest trouble with a carburetor comes from the passages getting clogged with dirt.

Threads of Cotton Waste Getting in the Tank will stick in the valve so that the carburetor will flood.

Anything That Obstructs the Flow of Gasoline will make the engine run unevenly, or stop it.

The Construction of the Carburetor Should Be Learned, so that it may easily be taken apart for cleaning, and put together again correctly.

In Taking It Apart remember the position of the gasoline and air adjustments, or mark them; so that they can be approximately replaced without losing time in readjustments.

If the Float Valve Is Clogged so that it will not close, the carburetor will flood, causing too rich a mixture.

The Needle Valve May Wear Sufficiently to Cause This, in which case it should be reground, the operation being similar to that of grinding in an engine valve.

Another Cause for a Flooding Carburetor Is a Leaky Float, or a cork float that becomes soggy.

Gasoline Corrodes Brass and Copper Slightly, and in time may cut a hole through a metal float and enter.

This, of Course, Makes the Float Heavier Than It Should Be, and as it will not float high enough on the gasoline, the valve will not close soon enough.

The Hole May Be Too Small to Be Seen Easily, but when the float is shaken the gasoline may be heard splashing inside.

The Soldered Joints of the Float May Also Break, admitting the liquid.

The Hole May Be Too Small to Pour the Gasoline Out Of, and the best way to get it out is to place the float in hot water.

The Heat Will Vaporize the Gasoline, and it will come out in the form of bubbles of vapor.

When the Float Is Empty, the hole should be plugged with solder, using as little as possible, and scraping off the surplus, that the weight of the float may be changed as little as may be.

Care Should Be Taken that a cork float does not chafe in rising and falling, for the dust of the shellac or varnish thus rubbed off may choke the spray nozzle.

The Main Air Intake of the Carburetor is sometimes protected by a screen of wire gauze to keep out the dust.

This Screen Will Often Get Oily, and will then hold the dust instead of permitting it to drop off.

This Will, of course, prevent the air from entering freely, and will result in a rich mixture.

Wash the Screen With Gasoline to remove the oil and to clean it, and keep it clean.

Long, Fine Steel Wire Should Be Carried in the Kit, to clean out the carburetor passages and the spray nozzle.

The Spray Nozzle is always placed so that these may be run through it.

Hat Pins or Wire Hair Pins are excellent for this.

BACKFIRING OR "POPPING" IN CARBURETOR.

Carburetor "Popping" or Backfiring, in nine cases out of ten, is caused by an unduly weak charge of mixture.

If the Jet of the Carburetor Chokes, or the gasoline supply runs short, it will often happen that a few exhaust-box explosions will accompany it, as a weak charge often misses fire altogether.

The Key to Avoid This Trouble is that a weak charge burns slowly.

If an Unduly Weak Charge Fires, it will be in a state of incandescence during the whole of the exhaust stroke, and the compression space and valve ports will be full of flaming gas.

The Inlet Valve Then Opens, some of this flame is drawn across till it meets the incoming fresh charge, this ignites, travels along the induction pipe and spurts out at the carburetor.

Sometimes It Catches the Spraying Gasoline; then a carburetor fire occurs.

It Is Rarely Through Any Defect of the Inlet Valve that popping occurs, at any rate, not with the mechanically operated valve, the strong spring of which ensures it closing tight.

Automatic Inlet Valves, However, have been known to "stick" or remain slightly open during the firing stroke.

A Fire-Back May, in Rare Instances, Be Due to the inlet valve opening a few degrees in advance of the exhaust valve quite closing, evidently an error in setting the timing gear.

TO LOCATE A MISFIRING CYLINDER.

If the Engine Is Misfiring Regularly in one or more cylinders, the source of trouble may be located by cautiously touching the separate exhaust pipes in turn. Those pipes which lead from the defective cylinders should be cooler than the others.

Another Method is to short circuit the plugs of each cylinder in turn, while the engine is running.

To Do This, a wooden-handled screwdriver should be held so that the metal blade is in contact with the cylinder head and with the terminal of the plug.

If the Cylinder Which Is Being Tested is firing correctly, this short-circuiting of the plug will reduce the speed of the engine.

When the Misfiring Cylinder Is Reached, no reduction in the engine speed will be noted.

UNUSUAL OCCURRENCES.

A Few Further Hints on more unusual sources of trouble may perhaps be of service on some occasion sooner or later.

(1) **If a Leak Is Caused in the Gasoline or Pressure Pipes,** a temporary repair may be effected by wrapping insulating tape round the fractured part. If insulating tape cannot be obtained a thin strip of cloth smeared with soap will make a good substitute.

(2) **If the Float or Needle Valve Is Damaged** so that the carburetor persistently floods, the gasoline tap should be gradually turned off until just sufficient petrol reaches the carburetor to enable the car to be driven at its normal speed.

In This Way the journey can be completed with the float or valve removed if necessary.

(3) **If, Especially in Cold Weather,** the engine appears to run sluggishly and fails to develop full power till after a considerable distance has been covered, the water in the radiator is probably too cold. In this case, the fan may be removed by withdrawing the four bolts which connect the blades to the boss. If there should be signs of overheating when the weather becomes warmer, the fan should be replaced.

UNUSUAL NOISES.

On Account of the Multitude of Moving Parts on a Car, slight squeaks or noises are sometimes set up. These noises may be especially noticeable, and hence a few words on their location may be useful.

If the Squeak Is Regular in Occurrence, it must be caused by some revolving part.

By Running the Engine with the car at rest, it can be determined whether the trouble is in this part or not.

If Not in the Engine, the squeak is probably in the clutch mechanism or in one of the universal joints, or perhaps the brakes are rubbing slightly on their drums.

A Few Minutes With the Oil Can will put these matters right.

If the Squeak Is Intermittent, the springs and spring shackles should be examined and lubricated.

When the Squeak Is Specially Noticeable on rough roads it is almost certain to be caused by one of these parts.

MISCELLANEOUS TROUBLES.

A Leak in the Compression Chamber may often be detected by cranking the engine with the ignition circuit open, the hiss of the escaping charge showing the location of the leak.

Leaks Are Liable to Occur at Any of the Openings Into the Cylinder; at the spark plug opening, or around the relief cock, for instance.

The Spark Plug and the Relief Cock May Be Made Tight by the Use of Copper-Asbestos Washers, or by a copper washer, that metal being soft enough to be forced into the rough places.

Leaky Valves may be ground in as described under "Repairs."

Leaks Will Affect the Operation of the Engine, in weakening the compression, diluting the fresh charge by the air that enters, the escape of the pressure during the power stroke, and the igniting of the mixture in the inlet pipe.

PISTON RINGS CUT AND SCRATCHED.

When the Piston Rings Have Been Cut and Scratched by Long Use, or running without oil, the leak will be into the crank case, and when this part heats so that it is uncomfortable to touch, it is an indication that it exists.

The Only Remedy Is the Reboring of the Cylinder, and the fitting of new piston rings.

Piston Rings Must Be Handled Carefully, for they are very brittle.

To Place New Ones in Position, bind pieces of thin steel, like bits of old hack saw blades, over the piston, to keep the rings from catching in the head and grooves.

Place the Lowest Ring in Position First, having tied the pieces of steel to the piston so that they end at the upper edge of the groove.

Then Move Them Upward, so that they end at the upper edge of the next groove, and proceed in this manner until all are in place.

When Piston Rings Are Not Pinned in Position so that they may work around in their grooves, they will move so that their spilt ends are in line, and this will often give the compression an opportunity to escape.

LOSS OF COMPRESSION SOMETIMES DUE TO A CRACK IN CYLINDER WALL.

For Loss of Compression that is not due to any of these things, it is probable that the cylinder wall, cylinder head, or piston head is cracked.

A Crack in the Cylinder Wall will admit water to the cylinder from the water jacket.

To Detect a Crack in the Piston Head, it must first be scraped clean of the carbon deposit.

LOOSE NUTS, ETC.

Loose Engine Parts Always Make a Noise that points to the trouble.

Loose Connecting Rods Will Pound at Every Explosion; loose main bearings will pound at every revolution; other loose parts rattle.

All Nuts and Bolts Must Be Kept Tight, and secured by lock nuts, which in turn may be kept in place by cotter pins.

And Play or Lost Motion in any part of the engine is liable to cause a smash, and do serious damage.

LUBRICATION IMPORTANT.

Lubrication Must Be Carefully Looked After, and the driver should assure himself as to the condition of every bearing.

Watch the Sight Feeds of the Lubricator, and keep it to its work.

When Dirt in the Oil Clogs the Pipes, they may be blown out with the tire pump, which is easier than trying to clear them with a wire.

Only the Best Oil Should Be Used, and even this is none too good for the use to which it is put, and the heat to which it is subjected.

WATCH THE COOLING SYSTEM.

If the Cooling System Fails to Do Its Work, the engine will heat, and if this continues, it will be ruined.

Shortly After the Engine Has Been Started, the radiator should begin to heat, and quickly get warm all over.

This Indicates that the water is circulating properly. ,

Failure of the Pump to Operate, or an obstruction of the passages, will prevent the circulation, and the radiators will not heat.

The Radiator Must Be Fully Exposed to the air in order that it may cool the water, and it should therefore be kept free from mud or heavy dust.

Rubber Hose Is Usually Used for the connections of the cooling system, and bits of rubber from it are liable to rot off and clog the pump.

This Is Apt to Happen at the Joints, which are clamped, for a bit of rubber may loosen at one end, and flap across the opening, acting like a valve.

The Water Used Must Be Clean, for dirty water will clog the pump.

A FREEZE MEANS CONSIDERABLE EXPENSE.

Water That Has Been Heated will, when cool, freeze more easily than water that has not been heated, so that the water in the system cannot be called safe from freezing because water standing in the street has not frozen.

***In Winter,** be on the safe side, and drain the system when leaving the car unless there is absolute assurance that the barn is warm enough to prevent freezing.

A Freeze Means Broken Piping, split radiator, and possibly a cracked water jacket; the few minutes that it takes to drain of the water is economy.

AN AIR-BOUND RADIATOR.

In Refilling the Radiator and System, be sure that it is not "air-bound."

By This It Is Meant that the air may collect in the pipes in such a manner that the water prevents it from escaping.

This May Be Sufficient to prevent the water from circulating.

EVEN AN AIR-COOLED ENGINE MUST HAVE ATTENTION.

The Parts of an Air-Cooled Engine Must Be Kept Clean, for mud or dirt on the flanges or pins will prevent the free radiation of the heat.

The Fan Must Be Kept Running at Its Best Speed, and the belt must be kept from slipping by tightening it and dressing the pulley with a good belt dressing or powdered resin.

---

*See page —— for Non-Freezing Solutions.

INSTRUCTION No. 30

DIGEST OF TROUBLES:—Their Cause and Remedy. Questions Asked and Answered.

ENGINE REFUSES TO START.

Look for Ignition Trouble: No spark, open switch, dirty spark plug or cracked porcelain, broken connection, vibrator blade stuck, switch plug loose, exhausted battery; if starting on magneto, crank not turned fast enough.

Look for Gasoline Trouble. Empty Gasoline tank, gasoline valve cock closed, water in carburetor, carburetor needs priming, air inlet at carburetor needs adjusting, water in cylinder from a crack, mixture too weak or too much gasoline.

When the Engine Refuses to Start on Being Cranked Eight or Ten Times, it is useless to continue; look for the trouble.

In Such a Case, after being sure that the gasoline is reaching the carburetor.

A Cloth or Cotton Waste Soaked With Gasoline Held at the Main Air Inlet will permit the engine to get a charge, or a few drops may be squirted into the cylinders through the relief cocks.

Do Not Crank the Engine Slowly—the faster the better.

ENGINE STARTS, BUT WILL NOT CONTINUE TO RUN.

Cause: (1) Storage battery run down. (2) Gasoline not flowing freely to carburetor. (3) Carburetor needs adjusting.

Remedy: Try the other battery (if there are two) or switch on to magneto. (2) See if tap is turned on fully; see if gauge shows correct pressure at tank; see if dirt in float chamber or pipes. Adjust carburetor.

ENGINE WILL NOT RUN FAST.

Cause: Storage battery weak. (2) Trembler requires adjustment. (3) Ignition retarded. (4) Magneto requires adjustment. (5) Muffler choked. (6) Carburetor needs adjusting.

Remedy: (1) Recharge the storage battery. (2) Adjust trembler. (3) See if ignition lever works the distributor correctly. (4) Adjust contact breaker. (5) Remove muffler and clean the tubes. Adjust carburetor.

ENGINE STOPS SUDDENLY.

Look for Ignition Trouble: Broken wire, missing spark plugs, loose connections on coil or wire broken under rubber insulation.

Sudden Stoppage Is Almost Always Due to Ignition Trouble, for gasoline trouble will stop engine more slowly.

The Sudden Stoppage of the Engine Is Caused by Any Opening of the Ignition Circuit That Cuts Off the Current, like a broken wire.

ENGINE STOPS SLOWLY, WITH MISFIRINGS.

Look for Ignition Trouble: Batteries exhausted, plugs fouled through over lubrication.

Look for Gasoline Trouble: Empty gasoline tank, supply cock jolted closed, carburetor choked with grit at jet or sediment in pipe, in pressure cars the pressure pipe may be leaking at one of the unions, tank air bound, gasoline pipe leaking, water in gasoline, needle valve in carburetor closed by jolting.

When an Engine Stops Slowly, the explosions becoming weaker and weaker until they cease, it is due to gasoline trouble.

The Fault Will Be Found in the Failure of the Mixture to reach the cylinder.

ENGINE MISSES EXPLOSIONS.

Look for Ignition Trouble. Loose connections, dirty spark plug, timer worn and not making regular contact exhausted, battery.

Look for Gasoline Trouble: Dirt in gasoline tank over outlet, dirt or water in carburetor, float leaking, jet in carburetor clogged up, supply cock loose, inlet valve sticking or leak in inlet pipe, weak exhaust valve spring.

If the Engine Misses, and the following explosion is accompanied by an explosion in the muffler, ignition is at fault, for the charge has reached the cylinder correctly, but has been exhausted without being exploded.

In the Muffler it has been Exploded by the Heat, or by the exhaust from the following explosion.

If the Engine Runs Well for a Time, and then misses badly, repeating this, the fault is most likely with the timer, which may be loose on its shaft, or the shaft may be loose in its bearings.

In Either of These Cases, the ground return is interrupted.

ENGINE DOES NOT DELIVER FULL POWER.

Look for: Overload, muffler may be clogged up with soot, loose throttle connection, look at valves or piston and compression, not good, carburetor chamber filled with carbon, pre-ignition, tight bearings, tight brake, faulty cooling, faulty lubrication—weak compression; caused by valves or piston rings leaking; may be an air inlet or in the inlet pipe.

Poor Compression and Improperly Adjusted Carburetor the principal causes of lack of power.

Faulty Cooling or Lublication will tend to make the piston stick or sieze, in the cylinder.

The Lubrication Is Known to be Safe When There Is a Faint Trace of Blue Smoke at the Exhaust, showing that the engine is being slightly over-lubricated.

If No Smoke Shows, there is no way of telling that the engine is getting enough oil, and it is best to be on the safe side—but do not overdo it.

ENGINE RUNS WELL, BUT CAR DRAGS.

Look for: Clutch slipping, oil on leather, spring wants tensioning, leather worn and wants renewing; if a metal plate, clutch springs at fault or plates worn.

ENGINE WILL NOT STOP WHEN SWITCHED OFF.

Cause: (1) If firing is regular, switch defective or wire disconnected. (2) If firing is irregular, pre-ignition, carbon on piston heads or plugs..

Remedy: (1) To stop the engine, shut the throttle; then examine switch and wiring. (2) Clean plugs; if necessary, clean burnt oil from cylinders by removing the heads.

ENGINE MISFIRES IRREGULARLY.

Cause: Ignition, carburetor.

Remedy: Examine contract breaker, distributor, wiring, switch, plugs, accumulator. See if there is any dirt or water in the float or jet chamber; see that the gasoline is flowing properly.

ENGINE FIRES IN MUFFLER.

Cause: (1) Quite often occurs when coasting and the spark is shut off and retarded and opened suddenly, thereby firing charges which have entered auto muffler unfired. (2) Mixture too weak to fire, or mixture right but sparking wrong, one-clyinder missing fire and pumping explosive charges into muffler, which ignites from heat of the next exhausted change. (4) Missing of ignition, valves leaking. (5) Gasoline supply failing.

Remedy: (1) Examine as in last section; particularly see if the plug points are too far apart. (2) See that all cylinders are firing regularly. (3) Adjust carburetor. (4) See if plenty of gasoline in tank.

EXPLOSIONS IN CARBURETOR OR INLET PIPE—OR BACK-FIRING IN CARBURETOR.

Cause. Valve timing not correct, inlet valve leaking, valves overheated, mixture too weak, ignition retarded too far, ignition timer out of order or not timed correctly.

Remedy: (1) Examine pressure and fuel supply; see if there is any dirt or water in the carburetor; see if the inlet pipe joints are loose. (2) Look for short circuits in timer. (3) See if valves are timed right. (4) Adjust carburetor.

ENGINE OVERHEATS: INDICATED BY WATER BOILING IN RADIATOR.

Cause: (1) Ignition too much retarded. (2) Want of water. (3) Circulation defective. (4) Fan not working. (5) Pump not working. (6) Radiator choked up. (7) Steam lock in pipes. (8) Driving too long on low gear. (9) Mixture too rich. (10) Using excess of gas. (11) Exhaust throttled too much. (12) Valve timing incorrect. (13) Muffler choked up.

Remedy: (1) Advance ignition lever. (2) Refill the radiator after the engine has cooled down somewhat. (3) Clean pipes out with soda (see instruction on "Cooling.") (4) Adjust fan belt. (5) See if pump-driving shaft is revolving. (6) See if valve timing is correct.

ENGINE REFUSES TO STOP.

Cause: Faulty lubrication, engine hot, pre-ignition or carbonized combustion space, faulty cooling.

This Condition Is Caused by the cylinder being so hot that the heat ignites the incoming charge.

When There Is a Considerable Carbon Deposit in the combustion space, points of the carbon will get white hot, and will remain so, igniting the incoming charge.

To Stop the Engine, shut off the gasoline supply, and as soon as the engine cools, locate the trouble and remove it.

Examine the Lubrication System, to be sure that the engine is getting enough oil.

If the Belt or Chain of the Water Pump has Run Off, replace it, and make sure that it cannot happen again.

If the Cooling System Is Clogged, clean it.

KNOCKS IN ENGINE.

Look for: Spark too much advanced, loose connecting rod or wrist pin, loose bearings, self-ignition, due to carbon in combustion, chamber red hot and causing pre-ignition, loose or worn bearings, cylinder loose or crank case through slack nuts.

If the Spark Is too Much Advanced, full power will be developed before the piston reaches the top of the compression stroke, and in continuing to move upward against the pressure will produce a knock.

Retard the Spark to the point at which the knock ceases.

It Often Happens that the Position of the Timer Slips, or its connections are loose, so that when the lever is in the retarded position, the timer is advanced.

This Will Produce the "Gas Knock," and readjustments should be made.

In Locating Trouble, the only thing necessary is common sense.

Before Doing Any Readjusting, be sure that you are right; it is no use to adjust the carburetor when ignition is at fault.

ENGINE MAKES AN UNUSUAL HISSING NOISE.

Cause: Spark plug porcelain broken, joint between engine and exhaust pipe loose, exhaust pipe cracked, compression tap worked loose.

ENGINE RUNS WELL, BUT WILL NOT DRIVE CAR.

Cause: Clutch slipping.

Remedy: Increase tension on spring, pour a little gasoline on leather; as a last resource, apply Fullers earth or resin to the leather.

ENGINE VERY DIFFICULT TO PULL AROUND FOR STARTING OR REFUSES TO MOVE AT ALL.

Cause: Engine may be "ingear." See gear lever is in neutral position. (This is very important.)—One or more pistons have seized. due to failure of lubrication, or use of inferior oil—Injection of kerosene into cylinder may remedy it.

OVERHEATING OF EXHAUST PIPE AND MUFFLER.

Cause: Carburetor trouble over-rich mixture, valves out of time, very late spark, Running too long on low gear, using too much gas, exhaust throttled, insufficient lift on valve or checked muffler.

This Condition Is the Result of something by which the mixture is not completely burned in the combustion space, but continues to burn in the exhaust pipe and muffler.

A Mixture That Is Too Rich or Too Poor, usually the former, will burn slowly and will still be burning during the exhaust stroke.

If the Exhaust Valve Opens Too Soon, the charge will escape before it has done its work.

Very Late Ignition will not give enough time to permit the charge to be burned before the exhaust valve opens.

CRANKCASE BECOMES VERY HOT AND ENGINE WEAK.

Cause: Serious leak of exploded gas past piston rings, rings worn or broken, crack in head of piston, gudgeon-pin loose in piston and allowing gas to escape along bearing.

QUESTIONS ASKED AND ANSWERED. (Miscellaneous.)

Useful Infomation in the Form of Questions and their Answers relative to Trouble of All Kinds.

NON-FIRING CYLINDER.

Q.—I have a two-cylinder car. Can you offer a suggestion as to the cause of the following difficulty, viz., the front cylinder will not fire unless I close the air inlet, whilst the back cylinder works well with full supply of air? I have tried new plugs, had the coil tested, and connected engine to the frame terminal on switch. I get some improvement if I flood the carburetor.

A.—Evidently the front cylinder requires an initially stronger mixture than the rear one, and this suggests that it is taking in air at some point. Investigate for possible air leakages between cylinder or carburetor. Of course, if this cylinder is not in as good condition as the other as regards compression, it will not run on so weak a mixture as the other one will. If the valves are automatic type, examine the springs; probably the valve sticks.

TREATMENT OF CLUTCH, ETC.

Q.—(1) I have just purchased a car with a leather cone clutch. Should the leather be oiled? It is quite dry at present, although it works well. (2) Should the distributor of the magneto be cleaned periodically? (3) I notice that the break between the platinum contacts is very small. I can only get a piece of notepaper in between. Is this correct? I was under the impression that it should be 1-16th inch.

A.—(1) A light dressing with castor oil once in 500 miles, running is good for the leather. It should be allowed to soak in well before the clutch is used. (2) Cleaning is only required at long intervals. It is better to follow the maker's instructions. Some carbon dust may accumulate in time, in which case it should be cleaned away from the contact surfaces with a clean piece of rag slightly oiled. (3) The maximum gap allowable on most magnetos is 1-50th inch, so you may regard the adjustment as correct.

Q.—How is the speed of an engine increased?

A.—By increasing size of valves, making piston lighter and increasing compression by lowering cylinder. High speed engines are generally the same bore and stroke. Long stroke engines as a rule run slower.

REMOVING A TIGHT FLY WHEEL.

Q.—Will you please inform me how to get a very tight fly wheel off the shaft? The engine is an early pattern, and no amount of hammering will shift the wheel on the shaft.

A.—You will have to use a wheel puller (See Fig. 1, Chart 156) which is a special tool designed for the purpose. The boss of the wheel should be warmed up with a blowpipe to expand it and then the tool applied. Hammering is very risky, insomuch as the shaft may be damaged.

EXPERIMENT IN "RUSTING-UP" A CRACK.

Q.—I am trying the experiment of "rusting-up" a small crack in the combustion chamber of one of my cylinders with ¼ lb. of sal-ammoniac to 1 quart of water. Please inform me: (1) How long should I leave the solution in the water jacket? (2) Should I wash out the water jacket with clean water after removing the sal-ammoniac, so as to remove superflous solution of same? (3) How long should I allow the cylinder to remain drying before using? That is, when should the rusting process be sufficiently complete?

A.—(1) Three-days at least. (2) Yes, very important, as the solution tends to corrode brass and copper of radiator. (3) Not necessary to let stand, as the rust, once properly formed, is insoluble. If no success results from the experiment, try Iron Cement, a preparation supplied by leading accessory houses.

SUDDEN FALLING-OFF IN POWER.

Q.—My two-cylinder car has recently given me trouble, the engine falling off in speed and power suddenly, then picking up vigorously, but continuing for a short time, with a misfire at regular intervals. I coupled the two four-volt accumulators in series, and got much improved results. Will this coupling together of the two batteries injure the coil? Do you think the storage batteries are being properly charged? My repairer suggests fitting a new carburetor, and installing a magneto. Would you advise me to adopt these **suggestions?**

A.—Before going to the expense of having a new carburetor and a magneto fitted you would do well to overhaul the ignition system. The symptoms certainly are not inconsistent with those of weak storage batteries, so it would be well to eliminate this possibility first by using a well-charged and reliable storage battery. If there is no improvement, go thoroughly over the wiring, see that every connection is clean and well screwed up, and pay particular attention to the contact make and break, because very often any looseness here will result in a bad frame connection.

EXPLOSION IN MUFFLER.

Q.—Please let me know how to remedy the following fault. When I have been driving a car full speed for a few miles, and then slow up a little, there is a sort of bang in the muffler. Is this through the mixture being at fault?

A.—The cause of the trouble is undue weakening of the mixture, which results in a misfired charge passing in to the muffler and exploding from the flame of the next fire charge. Carburetor requires attention.

MISFIRES ON COIL IGNITION.

Q.—Will you please suggest likely cause of trouble with a 20 h. p four-cylinder car fitted with dual ignition. When running on a magneto it is all that can be desired, but when switching over on to the storage battery and coil it misfires rather badly at high speed, but not when running slow. The storage battery is well up (shows 6 volts), and I have trimmed and cleaned the platinum contacts on the trembler, but this makes no difference.

A.—If the engine is fitted with a timer using a steel roller and fibre ring contact make and break it is most probable that the source of the trouble is here. The fibre ring and contacts should be turned up true in the lathe, or a new part fitted. Owing to wear the roller jumps off the contact at high speed and causes a misfire. We have experienced a similar trouble. Also advisable to see that all the connections are tight and clean, as a matter of precaution.

TO KEEP A WIND SHIELD FROM CLOUDING.

Q.—How can I keep my wind shield from clouding.

A.—A very practical method of keeping the wind shield from clouding in wet or cold weather is to rub a half-and-half mixture of kerosene and glycerine on the clouded surface of the glass. A small bottle of this mixture, tightly corked, may be wrapped in a little waste, put in a half pound baking powder can and stored away in the tool box or some other convenient place about the car. When it begins to rain pour a small portion of the mixture on the waste, rub over the damp surface of glass and all water will spread out in a thin sheet, wherever it comes in contact with the glycerine, instead of forming in little globules, which are so detrimental to the vision.

MISFIRES WHEN ADVANCED.

Q.—I have a 10-12 h. p. two-cylinder car, which lately has been giving me trouble, whether it is the ignition which is at fault or the carburetor I am unable to determine. The ignition is by coil and storage battery and make-and-break contact, and the carburetor is a multiple jet of standard type. I find when on the road the engine misfires, that is with the ignition advanced over halfway. It, however, fires quite evenly when started up with the ignition retarded, but directly I advance towards full, misfiring occurs, consequently I can get no speed out of the car. I have tried the effect of having different size jets in carburetor, but it appears to make no difference. I have observed at times that the carburetor "sweats," tiny drops of water standing on the outside; do you consider that it is getting too much cold air? I have no heating pipe connected from exhaust to carburetor, though there are connections for same, and I could soon fix a pipe if you think warmer air would be an advantage.

A.—Judging from the fact that the engine misfires when the ignition is advanced, it is quite likely that the sparking is weak. It would be well to make sure first of all that the storage battery is well charged, the contact maker well adjusted and all the connections are clean and tight. Also set the plug points close, not more than 1-32 inch apart. It is quite evident that the carburetor is not working well, and we consider this has a lot to do with the misfiring. Do as you suggest, so that the carburetor is well heated. The condensation shows that it is too cold, and, of course, this would mean weakening the mixture as soon as you get on the road.

MISSES FIRE UNDER LOAD.

Q.—My engine speeds up all right when standing, but misses fire under load, will you explain?

A.—If an engine speeds up nicely when the automobile is standing still and misses fire under a load you will know the batteries are getting weak. A good plan is to use two sets of cells alternately, as one weak cell will spoil a whole set.

PRE-IGNITION.

Q.—My car has done 11,000 miles running in very hilly country, and has lately developed a knock when ascending a hill. The cylinders have not been removed. Is this the result of carbon deposit?

A.—As the engine has not been cleaned out during such a long period of running, it is sure to be carbon deposit that is causing pre-ignition.

SPARK AND POWER.

Q.—Does a "fat" spark give more power than a thin one?

A.—A "fat" spark gives more power than a "lean" one. This may easily be demonstrated by anyone. Assuming that his car is equipped with a battery for starting, and a magneto, let him start it and drive a short distance on the battery, say up a grade. Apparently the car will be running well, but when about half way up let him throw the switch over onto the magneto circuit. The car will immediately give a leap and begin to accelerate.

What makes this difference in power? The battery gives a weaker current than the magneto; therefore the spark from the battery is comparatively weak and thin while the spark from the magneto is much "fatter" and hotter. I would say that a "fat" spark is a hot spark, and that the hotter the spark the more quickly will it ignite the gas. Now the battery spark, although it occurs at the same time as the other would, by reason of the difference of intensity, ignite the charge gradually. That is: instead of an instantaneous explosion at the occurrence of the spark, the engine gets over a trifle farther at the time of maximum pressure and the impulse is lighter because some of the compression is lost. Now the magneto spark being "fat" gives a more nearly instantaneous combustion which exerts a greater force and the power is therefore greater with the same mixture.

I have heard many experienced motorists say that the cost of extra gasoline consumed in running with a battery would pay for a magneto in a short time.

WATER CIRCULATION TROUBLE CLEAN RADIATOR.

Q.—Will you please help me out of a difficulty? My car insists on boiling the water away in 10 miles (6½ gallons). The water passes from bottom of radiator to bottom of cylinder, top of cylinder to top of tank, top of tank to pump, then to top of radiator. The pump is a centrifugal driven at crankshaft speed. The bottom of tank is level with top of cylinder. I do not think that the water circulates properly, as the radiator does not become hot like tank. The carburation is not quite satisfactory. Would an over-rich mixture cause the trouble?

A.—It is quite likely that the circulation system only requires well cleaning out. Fill up with soda solution (1 lb. soda to the gallon), and run for about five hours; then wash out thoroughly. You ought also to improve the carburation, as this has some effect in preventing overheating.

CARBURETOR ADJUSTMENT OF AIR VALVE.

Explain the adjustment principle of the auxiliary air inlet to the carburetor.

A.—Owing to the difficulty of designing a carburetor in which the proportions of air and gasoline can be held constant at very high as well as very low speeds, many designers of carburetors have resorted to the use of an auxilliary air valve. In a spring controlled valve, the tension of the spring increases as it is compressed: that is, as the air valve is drawn open by the suction of the motor and the spring tends to hold it closed, this tendency or pressure of the spring on the valve increases as the suction increases, and the proportion of air in the mixture is decreased and that of the gasoline increased. To overcome this a second or auxiliary valve is provided which, when the suction reaches a certain strength, opens and admits more air. Thus the auxiliary air valve is not brought into action until certain higher speeds are reached. The main air valve, then, should be adjusted for slow engine speeds and the auxiliary valve for high speeds. In ordinary practice, as the piano tuner tunes a piano, so does the mechanism tune up a motor, chiefly by its sound. In tuning up a motor, one generally adjusts the carburetor until the motor seems to run most harmoniously, then a test for power is made either by driving the car at speed or uphill. In the testing departments of a factory, various means are employed in testing the power of the motor, and when a carburetor has been adjusted so that the maximum power of the motor is obtainable, it is taken for granted that the mixture is right. Since the adjustments on almost all carburetors differ, it is difficult to give any set rules by which the correct proportions of its mixture may be known. Of course, it is well known that if there is a popping in the carburetor the mixture contains too much air and not enough gasoline, and if the exhaust has a pungent odor and the motor overheats, the mixture is too rich with gasoline; but while these are reliable indications of very rich or very poor mixtures, they do not show whether the fault is due to the adjustment of the carburetor or elsewhere. A mixture that is most powerful and at the same time most economical is almost impossible to obtain for all speeds of a motor, and the way to obtain the best mixture is to cut down the supply of gasoline in the mixture until the motor will give the best all around service.

DIFFERENCE BETWEEN HIGH AND LOW TENSION MAGNETOS.

Q.—What is the difference between a high and low-tension magneto?

A.—A low tension magneto has but one winding of wire on the armature and this winding is of from 500 to 600 turns. This magneto generates an electric current of approximately 60 to 100 volts pressure. Before this current can be delivered to a spark plug to give a spark in the cylinder it has to be sent through an induction coil generally carried on the dash of the car. This coil raises the voltage to perhaps 20,000 volts or higher so that there is enough pressure to bridge the gap of 1-32 inch between the points of the spark plug. Bear in mind that whenever a low-tension magneto is used there must be some form of induction coil to raise the voltage or pressure of the current, this coil either being a non-vibrating single-unit coil or a four-unit one. The situation is analogous to water used by a fire department. If the fire is in the top of a six-story building there must be pressure enough to throw the stream that high. In the electric current from the low-tension there is not enough pressure to throw the spark across the spark-plug gap. On the other hand, in the high tension magneto the armature carries two wire windings, one being 500 to 600 turns of coarse wire and outside of this a winding consisting of a 6,000 or more turns of very fine wire. It is this second armature winding that constitues the real difference between the high-tension and the low-tension magneto. In the high-tension magneto the coarse armature winding sets up a low-voltage current and the interruption of this current by the breaker box of the magneto sets up, or induces, a high-tension current in the fine wire winding of the armature, the same as a high-tension current is set up in an induction coil. In the high-tension magneto the outside induction coil is not needed and all that is needed are the wires from the magneto to the spark plugs. Because it creates the high-tension current within itself, the high-tension magneto requires a distributor built in it so that the current is sent to the proper spark plugs at the proper time.

WHAT IS A "MAKE AND BREAK" SYSTEM OF IGNITION?

A.—By make-and-break ignition is meant that type in which the ordinary spark plug is not used. The leading exponents of make-and-break ignition in America have been the Locomobile and Premier companies. In make-and-break systems instead of a spark plug there is what is designated a hammer-and-anvil arrangement within the combustion chamber, the hammer rocking against the anvil. This hammer is rocked to and fro from the camshaft so that when it rocks away from the anvil the electric current tending to complete the circuit follows in the form of a spark.

ENGINE HEATS.

Q.—My engine heats—how will I stop it?

A.—If your engine heats to such an extent that the water steams and boils away then it needs immediate attention but many cars run consistently well with the radiator about 200 Fahr.

First—Try running on spark lever well advanced—as much as possible without knocking. Try adjusting the carburetter and see if you can't cut down on the gasoline supply through the needle valve or nozzle—If you have a fan back of the radiator see if the belt slips—or possibly running this fan a little faster would help. If oil leaks past the piston rings this indicates that the compression is not so good as it might be. The piston rings are perhaps rather slack, and this would mean using more gas than should be necessary. Possibly, also, the timing of the ignition requires resetting. If it has not been periodically adjusted, that is, the tappet mechanism, it is sure to be firing slightly later than it should do, and this would cause heating. The valves are, of course, intended to open and shut exactly as the flywheel is marked, presuming that the tappets are set for the smallest clearance. Quite possibly there is an excess which would explain too early closing.

WHY A LATE SPARK HEATS THE ENGINE.

Q.—Will running with the spark lever retarded heat an engine?

A.—Yes, let us consider the case of a motor car requiring a certain power to drive it a certain speed. The heat generated in the cylinders increases approximately with the amount of gas burned. With a late spark more gas is required to develop the needed power, and thus more heat is generated in the cylinders. But as the same amount is converted into power, all of this added heat is lost either through the water jacket where it heats the water, or it passes out the exhaust, heating the valves and passages.

We have thus seen that a too late spark means less power with a given amount of gas, or in other words, less efficiency. Thus, less of the heat being converted into power, more is dissipated in the cooling water or lost through the exhaust, in both cases heating the motor.

THE USE OF THE SPARK AND THROTTLE LEVER.

Q.—Advise me how to use the spark and throttle lever in running—would you advance the spark and run on the throttle for varying speed?

A.—In operating a motor car it is not a good plan to advance the spark as far as it will go and then drive with the throttle as you suggest. This only can be done when traveling at a fairly high rate of speed. The spark always should be carried as far advanced as is possible to obtain the highest motor efficiency, that is, it should be advanced as far as possible without causing a knock or vibration. The skillful operator has almost as much use for a spark control lever as for the throttle lever. To maintain the proper equilibrium between the spark and throttle adjustment, both must be changed according to the speed of the motor. If traveling along on a smooth road at a fair rate of speed, the spark can be carried comparatively high and requires but little manipulation. But, if in driving on a crowded thoroughfare of a large city where it is necessary to slow down and again accelerate the speed of the car several times in each mile traveled, it is practical to use the spark lever almost as often as the throttle. For instance, in slowing down for a crossing or to avoid another vehicle, the slowing down can be done by simply retarding the throttle lever, but in picking up again the spark lever should be first retarded, the throttle opened, then the spark lever slowly advanced as far as possible to produce the best operation of the motor. Always retard the spark when subjecting the motor to a hard pull and always advance gradually.

The proper position of the spark when starting is just past top or outer dead center so that there will be no back fire. Once the motor is under way the spark is advanced so that it takes place before the piston reaches the outer or top dead center. It might be thought this would cause a back fire but in reality with a high motor speed the real effect of the explosion only occurs by the time the piston has passed the dead center, so that its energy is occurring at a desirable time. You will invariably find on climbing hills that the spark must be retarded so that the motor will not pound. The amount of retard depends considerably on the driver. One of the great errors in hill-climbing work is to let the speed of the motor drop; the speed of the motor should be regulated by the grade and length of the hill. If you have a short, steep hill, the speed can be kept high and the spark well advanced. For a long grade a low crankshaft speed will prove more satisfactory. Keep the spark advanced to the point just escaping a pound at all times.

Practice, alone, can properly teach the novice how to operate the spark and throttle lever.

ADJUST YOUR CARBURETOR ON TAKING A HILL.

Q.—Advise me how to adjust a carburetor.

A.—A faulty carburetor adjustment can sometimes be detected by the noises of the exhaust. An over-rich mixture, that is, a mixture containing too much gasoline, will give a heavy, ill-smelling smoke from the exhaust. When the engine is working hard with the spark advanced, a knock or pound will result. A mixture containing too much air is said to be weak. Indications of a weak mixture are popping sounds in the carburetter and after-firing or explosions in the muffler.

A leak in the feed pipe between the carburetor and the cylinder will cause a weak mixture by drawing air through the leak. The leak may be found by passing a rag, saturated with gasoline, along the pipe. An increase in engine speed will be noticed when the leak is covered. Excessive lubrication or a fault in the ignition wiring will cause trouble, therefore the oiling and ignition systems should be carefully gone over. If they are in good order the trouble most likely lies in the carburetor.

A good way to get an adjustment that will act equally well on hills as well as level roads is to adjust while going up a hill. The muffler should be cut out in order to notice results. For a rich mixture the gasoline feed supply should be decreased, when for a weak mixture the feed should be increased. The air valve after being properly adjusted will not require many changes in a season. In the air valve spring, however, lies the chief adljustment to begin with when fitting a new carburetor. After this original adjustment then adjust with the needle valve.

DISADVANTAGES OF A LONG INLET PIPE.

Q.—What, if any, are the disadvantages in having the inlet pipe small in diameter and of very considerable length? I ask because the inlet pipe of my engine is much smaller and longer than many I see on cars of about similar power. I do not seem to obtain the power I should do, and I have been wondering whether the inlet pipe has any bearing on this question.

A.—There are certain disadvantages in a long, narrow inlet pipe. Considerable resistance is offered to the flow of the gas, which prevents a full charge of mixture entering the cylinder; further, there will always be a tendency for condensation of gasoline vapor to take place because of the walls of the pipe remaining cold, thus weakening the mixture. The correct practice is to have a short inlet pipe of large bore with smooth interior and with large, easy bends. The diameter of inlet pipe should be at least equal to that of the inlet port and outlet of carburetor.

LOCATING NON-FIRING CYLINDER ON MAGNETO IGNITION.

Q.—I have had a high-tension magneto fitted to my four-cylinder engine. Will you tell me the best way to test which of the cylinders is not working with this ignition? Does it injure the magneto to disconnect three of the cables, leaving one connected?

A.—The usual method adopted is to disconnect the cables of three sparking plugs at a time, which can be done at the sockets on the magneto. This does not injure the machine, as the spark then takes place at the safety gap. Another method is to put three of the plugs to frame or earth. In some ways this is more convenient. A short piece of well-insulated wire is atttached to each plug terminal, and when it is required to cut off the spark at the plug points, the end is brought in contact with the engine. There are also plugs made with a short-circuiting switch; these are very convenient for locating a non-firing cylinder. Sparks passing at the magneto safety gap indicate that one or more cylinders are misfiring.

FIERCE CLUTCH.

Q.—I have an 8-h. p. single-cylinder car with a very fierce clutch. Coal oil seems to have no effect; washing with kerosene gives a fair result, but it has to be used freequently, and I am told that it injures the leather. The makers of the car sent me some springs to put under the leather, but there is not enough clearance between the inner and outer portions of the clutch for me to use them. Can you suggest any other dressing? I shall be grateful if you can, for I have quite used up three tires on the back wheel in running about 3,000 miles, and I think the damage to the covers may be partly due to the clutch.

A.—A mixture of black lead and glycerine applied to the leather often effects a cure. Possibly the clutch spring should be eased off with advantage. To be able to fit the springs under the leather, you may have to cut a series of shallow slots in the cone.

OILING A CLUTCH LEATHER.

Q.—I wish to soak clutch leather of my car in oil. Can you please tell me how long it ought to be soaked and in what kind of oil?

A.—The best plan is to dress the surface of leather with castor oil. Brush it on and let it soak in 24 hours. There is no need to remove the leather from the cone. In case it is a new leather you are fitting on, you can, of course, soak it in the oil.

LESSENING NOISE FROM VALVES.

Q.—The valves of my 12-16 h. p. four-cylinder car are noisy. I am informed that fitting pieces of vulcanized fibre to the leads of the tappets will remedy this defect. Please advise me on the following:—(1) Is the wear on the fibre likely to be excessive? (2) What thickness of fibre should be employed? (3) How should the fibre be fixed to the tappets? (4) Also can you tell me a good paint for the rims, which does not become sticky by the heat caused in running, this causing the tires to adhere?

A.—(1) No, the wear would not be great. In any case, you can easily renew them. (2) Say, 3-16ths in. hard fibre. (3) The fibre discs should be tightly pressed into steel caps, which fit on the tappet, and preferably made adjustable. (4) We have found an ordinary slow-drying enamel satisfactory.

PITTED VALVES.

Q.—The exhaust valves on my engine are very badly pitted. I shall be obliged if you will tell me if I have them skimmed up in a lathe shall I have to take some off the stems? What is the correct clearance between stem and tappets? What is the method of grinding in needle valve of carburetor?

A.—(1) The valves will come down a shade lower in the seats, and if the tappets are not adjustable you may have to file the ends to give the necessary clearance, which should not exceed 1-32nd in. Less than this even will allow for the expansion of valve stem when it becomes heated. (2) Apply a touch of crocus powder and oil to the valve and twirl it round slightly on its seating. A very small amount of grinding is usually enough to make the valve tight. Excessive grinding will upset the adjustment of the carburetor.

CARBURATION TROUBLE.

Q.—Will you let me know what you consider wrong with my engine, a two-cylinder horizontal, 12-h. p., mechanical valves. One cylinder is much slower than the other and on taking out the exhaust and inlet valves, I find same are covered with a black deposit after quite a short run, the other cylinder being quite normal as regards deposit on valves. The timing of valves is identical for both cylinders, and exhaust valve apparently shuts down on its seating all right, as compression is good.

A.—It is evident from the deposit of carbon on the valves that one cylinder takes in too rich mixture, and the combustion is incomplete, and power is lost. In some instances this is due to arrangement of inlet piping. You might effect an improvement by providing an adjustable air port on the inlet pipe leading to the defective cylinder. By careful trial, you may be able to weaken the mixture enough to overcome the trouble. Owing to the two firing periods in the usual two-cylinder engine following each other in succession, the carburetor requires very careful setting to avoid flooding on the second suction stroke.

IGNITION SYSTEM DAMP.

Q.—My 16-20 h. p. car is fitted with accumulator ignition only, and is running very badly just now. I have thoroughly cleaned all the sparking plugs and dried the porcelain insulators. I ran the engine in the motor house in darkness and found that sparks were to be seen quite clearly through the porcelain of three of the plugs; also a constant spark occurred at the switch, and the coil seemed to be sparking all over. There was also an occasional spark at the commutator. The coil was sent to the makers a few months ago and was supposed to be made as good as new. The commutator was new at the same time. Can you suggest a reason for this?

A.—It is difficult to understand how sparks can be visible through the porcelains. Are you sure they do not occur outside? You may have the plug points too far apart, thus causing the spark to jump across the porcelain from the terminal set to 1-40th in. It is evident, also, that the coil case has become damp on outside. Place it in warm atmosphere for 24 hours (but not near a fire). This ought to stop the leakage. The motor house may be damp. The spark at the switch suggests a loose contact or terimnal connection.

ENGINE "KNOCK" AND FIXED TIMING.

Q.—I have a 14-16 h. p. car, bought new in July, 1909, in which the timing of the magneto ignition is fixed. I have recently noticed, when approaching the top of a hill, that there is a "knock" in the engine. It always happens when the car is slowed down on the top speed before it reaches the crown of the hill, and when the engine might be said to be "laboring." The releasing of the throttle pedal down to a minimum usually causes the knock to disappear, but, of course, the car almost stops then. I do not see how it can be due to any carbon deposit accumulated at the piston head, as I have never been troubled with a foul sparking plug, and I have been lubricating pretty liberally, as the engine requires a lot of oil. Could you give me an idea as to the cause and remedy for the knocking?

A.—As a timing is fixed, it is very important not to allow the engine to reach the "laboring" stage before changing gear. With the variable timing it is possible to prevent knocking by slightly retarding the ignition when breasting a hill. It is not at all unlikely that the cylinders are actually foul, in view of the fact that the engine has been run over-lubricated; in any case, the cylinders should be cleaned after the first 2,500 miles. Any accumulation of carbon will accentuate the risk of knocking with fixed timing. It occasionally happens that the firing point is set a shade too much forward; it varies with different types of engine; in some cases as much as four millimeters advance can be given; in others it is found best to set the ignition point at the dead center. You could easily set it back a little and note result when hill-climbing.

WEAK COMPRESSION IN FRONT CYLINDER.

Q.—The engine of my two-cylinder car has lately fallen off in power. I have had a compression gauge made to screw into the plug holes. The front cylinder, on the starting handle being pulled up quickly, shows 35 lb. per sq. in., but if slowly pulled over only about 10 lb. is registered, and if the handle is stopped the pressure immediately falls back to zero. The back cylinder shows 68 lb. on a quick pull-up, 35 lb, slowly, and if the handle is stopped about 30 lb. for 15 seconds, when the gauge needle slowly goes back to zero. The piston rings are quite bright and clean, and the cylinders, as far as can be gauged by callipers, appear to be true and smooth. In the front cylinder and second piston rings have turned round, so that the slots are in line, but the opening of the lower ring is on the opposite side. The rings on the cylinder were in the proper position. In addition to grinding in the valves, what can I do to increase the compression in the front cylinder? Would there be any use in fitting new piston rings? What should the compression gauge register, presuming everything is right? Should the exhaust valve springs be stronger than the inlet? In my engine all the springs seem about equal strength. How is it possible to know whether the valves require new springs? The car has been running about four years. What pressure in pounds should be required to compress the different springs?

The back cylinder fires from 1-8 in. to a 1-4 in. earlier in the stroke than the front cylinder. Does this matter, and, if so, how can I remedy it? The contacts of the commutator are, of course, fixed, and I cannot alter them.

A.—The back cylinder may be regarded as in good order. The maximum compression obtainable is not likely to be more than 70 lb. to 75 lb. You would get this when the engine is running fast. To locate the fault in the front cylinder test the valve cap seats, also plug joints to see if quite tight. If so, the piston rings are probably at fault; the slits ought to be 120 degrees apart. If new rings are fitted, it would be best to have cylinder ground out true before the rings are fitted. An ordinary calliper test is not accurate enough. The bore must be tested with a micrometer, reading at least to 1-1,000th; instruments are used which read 1-10,000th. As regards testing the valves for tightness, you must be guided by results and appearance of valve face and seating after grinding in. Sometimes valves are tested with kerosene, a small quantity being poured over them, and if it is found that none leaks past after, say, an hour, the seatings may be regarded as tight. It is usual to fit valve springs of equal strength, so that these are interchangeable. It is not possible to say what the strength should be; there is no standard in springs, but a safe rule is to have the lightest tension which will ensure the valves shutting properly and prevent the exhaust opening on the suction stroke. Excess of strength simply means extra thrust and wear on the camshaft bearings and also wear of the cams. As regards the back cylinder firing earlier than the other, this is clearly due to a defect in the contact breaker. One of the sectors is either worn so that contact with the brush is delayed, or the sectors have not been set in exactly the right position relative to each other. It ought to be possible to have the contact made right.

INLET VALVES STICKING.

Q.—My car is a 10-12 h. p., four cylinders. Inlet valves of two front cylinders become gummed up and stick about every 50 miles; all others work freely. I use the best quality oil in the engine, and do not over-lubricate. What is the probable cause? About what is the average life of a set of piston rings?

A.—Leaky piston rings, most probably, causing an excess of oil to reach heads of cylinders. The average life of a set of piston rings is 10,000 miles. It is a matter of accurate fitting, good material, ample surface and lubrication.

RAISING THE COMPRESSION.

Q.—I have an 18 h. p. car, of a well-known and standard make, which has very low compression, and is weak on hills. Would you advise me whether it is safe to fix metal plates on the piston heads to increase compression, or would it alter the balance adversely? If you advise increasing compression, what thickness should the plates be for fitting on the pistons?

A.—We do not advise fitting plates to the piston, as the compression volume, as provided by the makers, is probably correct. Evidently there is a loss of compression rather than incorrect compression ratio, and for this you must look to the piston rings or valves. Raising the compression may cause preignition and increase the vibration.

CARBURETOR FLOODING.

Q.—Can you assist me to solve this dfficulty with my car? It is a 20-24 h. p. of very good make, with four cylinders, coil and Bosch magneto ignition: (1) After going down a hill with clutch either in or out, the engine fails to pick up on opening the throttle. It seems to "choke" for about a dozen yards, then engine picks up and goes all right. (2) When the car is standing the engine runs steadily for a few minutes, then gradually dies down, and if I give more gas it does not take effect and engine stops. On starting up again, I have to turn starting handle a dozen times where it will, when cold, start at the second turn. Again, if, when it dies down on standing, I switch off before stopping, I can start up on the second turn, but if I stop and then switch off it will not start under a dozen turns.

A.—The cause is certainly carburation defect, most probably the carburetor is flooding badly and upsetting the mixture. This causes "choking." Examine the float carefully, possibly it leaks, and grind the needle valve in. Possibly, also, the air supply requires resetting. The engine runs erractically because of the excess of petrol at the jet, and as soon as this has vaporated you get the mixture right again. You can usually start an engine more easily by switching off instead of cutting off the gas at the throttle, because this ensures an explosive charge remaining in one or other of the cylinders.

HOW TO CARRY EXTRA INNER TUBES.

Q.—What is the best way to carry an inner tube?

A.—Deflate tube powder the tube with a generous amount of talcum powder, then wrap in a piece of canton flannel or cheesecloth and pack in a small wood box with a sliding top; this will protect tube indefinitely.

FIRING AFTER THE CIRCUIT IS BROKEN.

Q.—After opening the switch on my car to stop the engine, it slows down to a low speed and nearly stops and then fires again several times, apparently on center, after which it back-fires through the carburetor and then stops. This seems to have a racking effect on the mechanism. I at first thought that it might be caused by carbon deposits; but the trouble still occurs frequently, even after the cylinders have been thoroughly cleaned of all traces of deposit. Please advise me what to do about it.

A.—Your trouble is one of frequent occurrence with engines in which the compression is quite high. The least carbon deposit will, in such an engine, often become incandescent while the engine is running, even though there is no indication that the engine is running at all hot. Still, several other things besides carbon deposit can cause this same action. It may be that there is some small, thin projection in one of your combustion chambers due to imperfect registry of the cores when casting the cylinder in question. If this is the case, the "sliver" of metal becomes very hot and will cause ignitions after the circuit has been broken at the switch. Again, certain spark plugs are prone to cause this same action in engines of high compression. Reference is had to those plugs in which one or the other of the electrodes within the cylinder is a long, thin wire. Under conditions favorable for it, these wires become so hot as to cause automatic ignition, as in your case. Plugs of this kind are rarely met with in these days.

HOW OFTEN TO GRIND VALVES.

Q.—I grind my valves every 500 miles. Is this correct?

A.—You ought to get a very much longer life from the exhaust valves than 500 miles; 4,000 miles is an average life, but longer runs than this are not unusual. The causes of scaling and pitting are throttling of the exhaust, causing overheating. Water not circulating round the valves, mixture not correctly proportioned, and ignition timing not sufficiently advanced. See that all the valves have full lift.

HOW OFTEN TO CLEAN CRANKCASE.

Q.—How often should I clean my crankcase—I have difficulty in starting on my magneto?

A.—An occasional cleanout of the crankcase is recommended by some makers after each 1,000 miles run.

A.—You have the sparking points too far apart for running on the magneto. This explains your difficulty in starting up. 1-50 inch is a correct width of gap.

PISTON RING LEAKAGE.

Q.—I have taken down my engine in search of the cause for loss of power, and find that the piston rings do not close up. When in position in the working part of the cylinder, a space exists between the ends, wide enough for a thin card to pass freely between. All the rings are in about the same condition. Will you please see if this would account for loss of power and, to my mind, compression? The engine is a 20 h. p., new last May, and was sent out of the works without the cylinder being ground, so I understand. Knowing this, I discarded the old piston rings, and the ones in question are quite new, and the change has made no difference to the running. The valves, magneto and carburetor are in perfect order. I can get full speed from engine when it is free, but when the clutch is let in there is no immediate response to accelerator, and the car begins to "get away" about 200 yards after the accelerator has been opened, and will not take any slight hill on "top." When I hold the cylinders on compression the sound of escaping pressure is distinctly heard with one's ears placed to the pump. I feel convinced that the loss of power is due to wear on cylinders, and that the only remedy is grinding the cylinders out and fitting special rings or new pistons.

A. It is not desirable that the ends of the piston rings should come quite close together; a small amount of clearance is necessary. We do not attribute the loss of power to the slight gap existing; but as you can distinctly hear a leakage of pressure into the crankcase ,it is clear that the rings and the cylinder bores do not fit perfectly. It is important to have cylinders tested wih a micrometer before fitting new rings, and have the bore ground out if it is not truly circular and parallel; this latter defect is, in fact, rather a common one. Of course, the engine was clearly sent out in a defective state if the cylinders were not ground after boring.

A WEAK ENGINE.

Q.—I have a four-cylinder engine, which is weak. I have ground in the valves, tried different adjustments of the carburetor, the ignition is in good order, tappets are adjusted close up (thickness of paper clearance). Should I get better results with more clearance? What is the correct space? Would retiming of valves have any effect on power?

A.—The valve clearance is quite correct, but it is quite possible that you have not got the best timing. (Full directions and diagrams on timing are given in this Instruction. Also see that you have the compression as good as possible. If the engine is still weak, try another carburetor.

ANOTHER CAUSE FOR LOSS OF POWER.

Too weak a spring on the exhaust valve will cause the valve to open on the induction stroke, and some of the burnt charge will be drawn back into the cylinder from the exhaust pipe and muffler. This will weaken the fresh charge considerably and result in less power being developed.

A MAGNETO DIFFICULTY.

Q.—I have two 20 h. p. cars; each has a two-cylinder engine. Car A is fitted with Bosch fixed timing magneto and standard type of carburetor. B has another make variable timing magneto and also a good make of carburetor. Both have accumulators also, and both cars run excellently. The engine of A will run dead slow on the magneto when the car is at rest and engine free. The engine of B will not (with ignition retarded), but it will run quite slow on the accumulators. Both magnetos are chain-driven, and I have tried setting the magneto of B a tooth forward and a tooth back (also two teeth) with no improvement in regard to slow running; the magneto of B dates from 1907, and has given no trouble, and the car runs quite well on it, but not when throtled down—the engine is apt to stop. I am anxious to get engine of car B to run slowly on magneto as it is driven by a lady, and the stoppages and racing of the engine are a nuisance. Can I do anything to improve matters? So far as I know the magneto of B has not been touched since I got it.

A.—A probable explanation is that the platinum contacts of magneto of B require adjusting closer. Too early a break of the circuit causes a weak spark when retarded. It is also possible that the magnets may also have lost some strength after about every three to four years of constant use a magneto should be remagnetized, and the distributor overhauled, because the wear of the sectors and certain small parts disturbs the accuracy of timing. It will be as well to note that the plug points are close enough, i. e., half a millimetre. Evidently it is much more likely to be the magneto than the carburetor which is at fault, because the engine runs well on the accumulator and coil ignition. The earlier types of magneto were not so good for slow running and ease of starting up as the newer types, owing to the comparatively weak spark obtained at slow speeds of armature rotation.

SOME CAUSES OF MISFIRING.

Q.—What causes "misfiring."

A.—What is meant by misfiring is the engine failing to burn all the charges that are taken to the cylinder. Batteries cause misfiring when in a run-down condition. An improper mixture is many times the cause of misfiring, for a mixture can be so rich that it cannot be ignited, or it may be so weak that it will not ignite, and much depends on the proper mixture as will be found in making a study of carburetor troubles. In case the batteries are weak and the mixture is known to be correct close the points of the spark plug a little if new batteries are not obtainable.

If some of the electrical connections are shaky, it will make only a partial contact and the engine will misfire. If the vibrators on the coil are not properly adjusted this will also cause misfiring. Misfiring is caused by the platinum points becoming pitted and sticking together, in this case the adjusting screw holding the platinum should be taken out and the points smoothed up with fine emery cloth. A file will do in a pinch but it cuts away the platinum quite fast.

A spark plug covered with soot and oil will cause misfiring and should be washed with gasoline and the points cleaned with sand or emery paper. In case the plug is of the porcelain type, a solution of one part muriatic acid and ten parts water may be used to clean them. Place the solution in a glass vessel and leave the plug to soak for 5 or 6 hours. This will remove the hard scale that forms on the inside. An over supply of lubricating oil in the cylinder will cause misfiring many times, or a poor grade of cylinder oil adds much to the misfiring troubles.

The timer becoming dirty and covered with oil many times causes misfiring. In this case wash it with kerosene to remove the dirt. A loose smitch will cause misfiring and some little attention should be paid it as it is used a great deal and must wear more or less. The switch plug is removed and replaced many times during the day and is subject to a great amount of wear and some attention should be given it in case of misfiring.

Leaky valves cause misfiring and a great loss of power. If the intake valve be in bad condition, it has a tendency to drive the incoming charge back down the admission pipe and the motor does not get the proper charge when it should. Valves effect compression and compression means power. Watch them.

MISFIRES WHEN RUNNING SLOW.

A.—An engine which works well at ordinary speeds miss when running slowly, because of one or more of the following reasons: when the cause of trouble is found it suggests the cure:

An air leak somewhere between the carburetor and cylinders, perhaps around worn inlet valve stems; this will dilute the normal mixture more at low speeds than at high, and if the engine is running slowly because of being throttled, the greater suction increases the leakage at the very time when because of reduced "gas" supply the most harm is done.

At low speeds and open throttle the compression is greater and sparking is thereby rendered more difficult; with an indifferent coil, a weak battery, or with most magnetos this is a real but sometimes unrecognized trouble.

The carburetor may be unsuitable for low speeds, or it may lack proper adjustment and at such times give either a too poor or too rich mixture; varying the supply of gasoline or of air will settle this point.

UP-KEEP EXPENSE.

Experience of One Motorist.

I bought a $2,000 car eight months ago, and have run it a little over 10,000 miles, and my expenses have been as follows:

833 gallons gasoline at 11 cents	$ 91.60
Five extra tires	216.55
Oil and grease	12.30
Insurance	20.00
Repairs, tires, etc.	20.10
Sundries, plugs, license, wheel tax, etc.	46.73
Depriciation, 20 per cent of cost	400.00
Interest at 6 per cent on investment	120.00
	$927.28

Figuring cost per mile the actual cash spent is $407.28, but figuring depreciation and interest it is $927.28, which I think is the only correct way. This is my fourth year, and I find it averages about the same each year.

LEAKAGE OF COMPRESSION.

LOSS OF POWER.

Q.—My engine does not develop the power it did when new. I am inclined to believe it has lost its compression, whatever that means. Will you explain what compression means? My repair man said this was the trouble.

A.—It can be recommended to those troubled with a weak engine to first of all test the sparking plugs for a compression leak at the washer seating between engine and plug. It can be easily done by smearing a film of thick oil round the joint and pulling the engine round. Any hissing or fizzling at the joint will at once indicate a leak. The writer experienced an instance of this kind. The plug in the front cylinder had fouled, and he replaced it with one which, as events showed, apparently had a taper thread, and which would not screw right home. It was screwed up as tight as possible, and the missing fire ceased, but after a few miles the power fell off alarmingly, the car failing to take the slightest rise unless the lowest gear was put in. He suspected loss of compression, and tried each cylinder separately, and found the front one unmistakably weak. He immediately tested the plug with oil, as previously mentioned, and straight away located the cause of the trouble. A slight leakage of compression sometimes occurs past the piston rings and causes the crank case to heat up. If the piston rings are examined a black patch on the surface indicates that gas is escaping past. The remedy is to have a new set of rings fitted. Compression leakage due to valve defects is dealt with elsewhere.

COIL REQUIRES ADJUSTMENT.

Q.—I have a four-cylinder car with storage battery ignition, coil with four vibrators, and wipe contact. I have fitted new blades to the contact and newly wired the car. Owing to the trouble of the platinum contacts on the coil constantly burning away and getting "stuck," and having to file them every few miles, I can never depend on all four cylinders firing properly. Can you tell me of a remedy?

A.—The coil is evidently taking too much current. Adjust the tremblers much lighter, and it would be worth while trying whether the coil will work with lower voltage. We assume that you are not using over six-volt battery.

GASOLINE AND OIL.

Q.—What test of gasoline is best for cold weather, 68, 74 or 88? Would it do to mix 68 and 88, or is it better to use either one or the other separately? Would it be any help to cover the pipes that lead from the carburetor to the cylinders with asbestos to keep the cold air away and would it help to cover the carburetor? If calcium chloride is used to prevent freezing, will it leave any deposit on the cylinders or pipes of the radiator if it is filtered properly? Which is the best grease to use in the transmission—hard oil, graphite or heavy cylinder oil?

A.—A 76 test is considered good gasoline to use for all ordinary automobile purposes. It would be advantageous to have induction pipes covered in cold weather to prevent them from freezing. Practically no deposit will be left in cylinders or pipes if calcium chloride is filtered before using. At 5 or 6 degrees below zero glycerine becomes a pasty mass, but soon liquifies after the motor has been running a few minutes. A heavy oil is preferable in the transmission, as the splashing of oil insures a good lubrication to all moving parts.

HOW TO SELECT A SECOND-HAND CAR.

Q.—Will you give me a few pointers on how to test a second-hand car with a view of purchasing it. I do not know much about automobiles, but if you will give me a set of rules to follow I will be obliged.

A.—Ascertain the age, make and type. Are the makers still in business, with a view of being able to get spare parts. Get exact dimensions of the cylinder and approximate number of revolutions and apply the formula given under horse power and obtain an idea of what the power really should be. Do not get an ugly or antiquated looking car—you may want to sell it again. Inspect its general condition. Inspect the transmission and condition of its gear wheels will show how much wear it has had. If chain-driven the wear can be judged by the condition of the chain. Jack up back axle and revolve the wheels and see if the differential works and if it runs true—same with steering wheels, also the steering gear; any considerable back lash is a bad sign. Examine tires, see make, then inquire of tire makers and see if the particular size can be obtained and is not obsolete. Test Engine for good compression. Run engine, if it knocks or rattles it is a bad sign. It should respond easily to the ignition and should slow down and run very slow. Inspect the radiator system and see that no botched up leaks exist. The water ought not to steam but will naturally get warm. Examine the Ignition and wiring system. For a final test run the car with a full load of passengers—make a 25-mile run with at least one good, steep hill, 1 to 8. A car which will not go up such a hill is of little practical use. Note if engine pounds when making the run and after the run note if bearings are hot and if water is steaming. Do not judge a car by its outside appearance—paint is cheap.

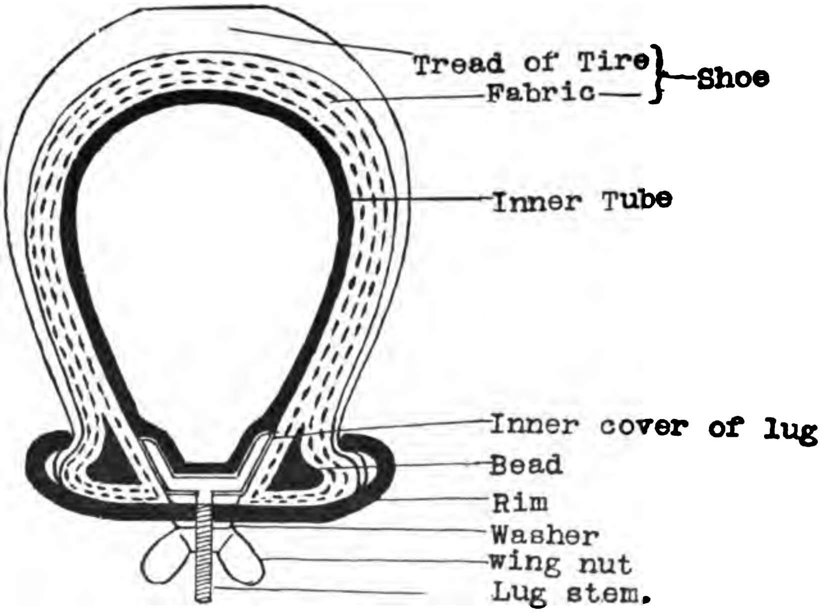


Fig. 1—A Standard Double Tube Pneumatic Tire Mounted on a "Clincher" Rim

This tire could also be mounted on a Standard Universal Quick Detachable Rim as shown in Fig. 1, Chart 139.

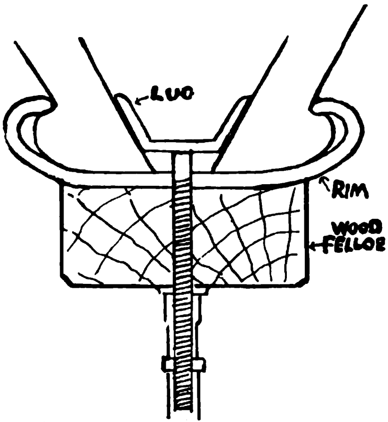


Fig. 2—Sectional View Showing How the Tire is Held on the Clincher Rim by a Lug, the bolt of the lug passing through the felloe of the wheel.

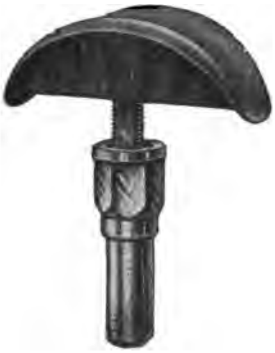


Fig. 2A—A Stay Bolt, or Lug for holding a tire to rim, see fig. 2.

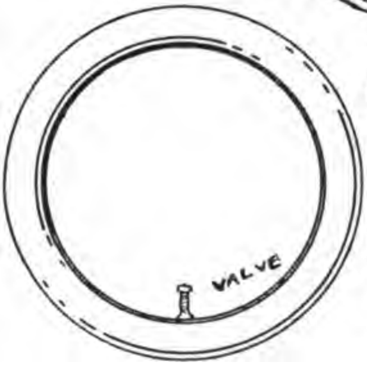


Fig. 3—The Inner Tube is Placed Inside of the Outer Cover.

Note the tube is an endless type of tube with a valve stem.

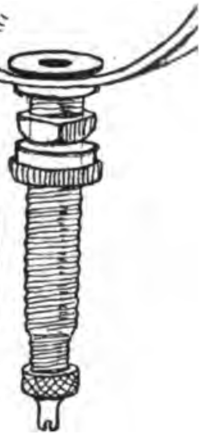


Fig. 4—Inner Tube Valve.

Note how the valve and stem is clamped to the tube.

Construction of a Double Tube Tire, Mounted on a Clincher Rim

CHART No. 136

INSTRUCTION No. 31

TIRES:—Clincher. Quick Detachable. Quick Detachable Demountable. Putting On and Taking Off Tires.

PNEUMATIC TIRES.

Pneumatic Tires give more trouble than any other part of an automobile, and the tire bills are always heavy.

With a Good Understanding of the Construction and Care of Tires, the expense may be cut down, although not entirely prevented.

In a Horse Drawn Vehicle, the springs, with sometimes small solid rubber tires, are depended on to absorb the vibrations of the road.

The Greater Weight of an Automobile, and its more delicate construction, require an additional protection against the vibrations that are too sudden for the springs to take up.

Pneumatic Tires Also Give Good Traction, which means grip on the road against slipping.

With Pneumatic Tires, the car is suspended on air, which is the most elastic of substances.

The Air Is Confined in a Rubber Casing That Is Free to Change Its Shape according to the surface of the road.

The Air Being Compressed, the casing must be strong enough to resist bursting.

CONSTRUCTION OF A PNEUMATIC (CLINCHER TYPE) DOUBLE-TUBE TIRE.

A Pneumatic Tire Consists of Two Chief Parts, the INNER TUBE, which holds the air, and the SHOE, or CASING, which retains the inner tube, and protects it from wear. (See Chart 136, Fig. 1.)

A Steel Rim Is Placed Around the Felloe of the Wheel, and shaped to fit the tire, its exact shape depending on the design of the tire. The clincher rim being the style universally used.

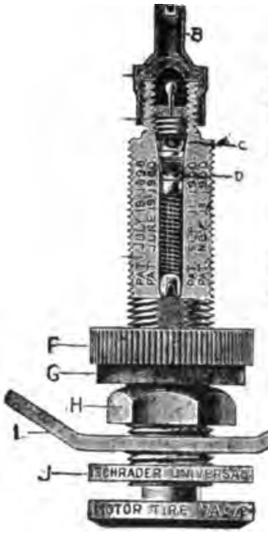
Double Tube Tires have projections on the shoe that fit under grooves at the sides of the rim, the pressure of the air in the inner tube holding them in place. (Fig. 1.)

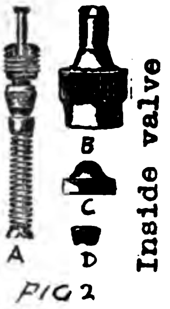
Bolts, Separate From the Tire and Called Lugs, or STAYBOLTS or SECURITY BOLTS, (Fig. 2) they pass through the felloe and rim, their large rubber or canvas-covered heads holding the extreme inner edges of the shoe against the rim.

The Parts of a Shoe Are Tread, which is the part that comes in contact with the road, the SIDES, and the BEAD, which is the projection at the edges that fit under the grooves of the rim.

The Shoe Is Made of Layers of Cloth Fabric, covered with rubber, and VULCANIZED together to form one piece, the greatest thickness being at the tread.

Rubber Is Vulcanized by Heating it under pressure, so that several pieces may be formed into one by the melting of the rubber.





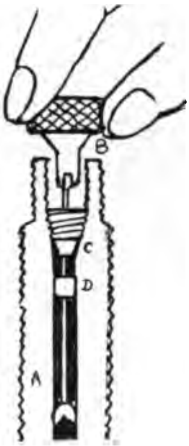


Fig. 3

Fig. 2—Shows the Inner Valve

Fig 3 — Shows how the valve cap B is reversed to unscrew the inner valve when tube is to be deflated and rolled up.

Fig. 1—Illustrating the Schrader Valve

The valve is attached to an inner tube as shown in fig. 4, Chart 136. The pump is attached to the end of valve and the air pumped into the tube. The inner valve A keeps the air from getting out.

B—Valve cap, must be taken off to attach pump connection.

C—Rubber valve inside of the inner valve.

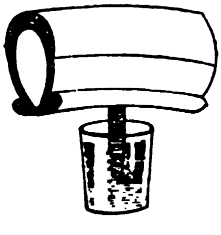


Fig. 4 — Simple Test for Air Leakage at a Valve by immersing in water and observing if any bubbles escape. Any leakage will probably be due to the small rubber valve plug C (fig. 2) having become defective.

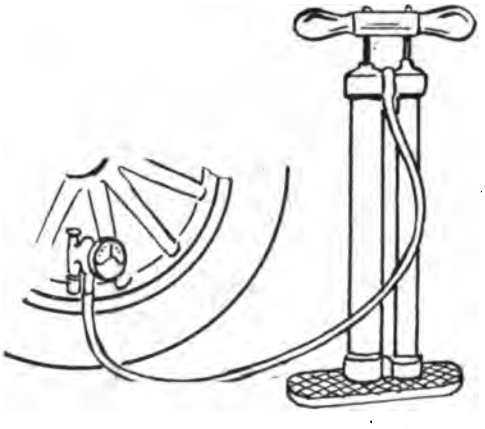


Fig. 5—Showing Method of Attaching a Compound Air Pump with a Pressure Gauge to Valve for pumping up tires.

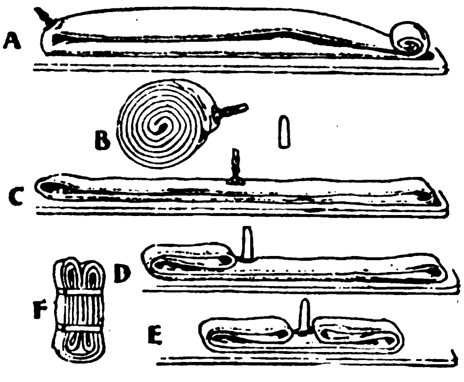


Fig. 6—Showing Method to Properly Roll an Inner Tube, to Carry as an Extra or to Lay Away. The inner valve (fig. 2) is generally removed as shown in fig. 2 in this case.

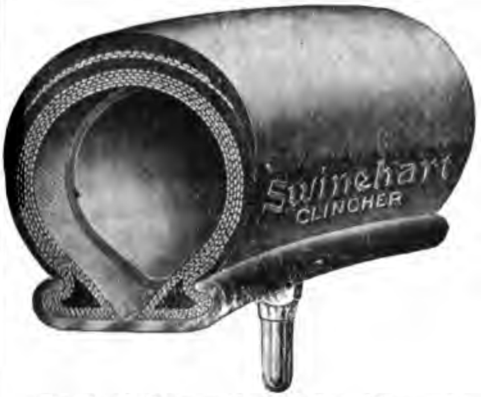


Fig. 1—A Pneumatic Clincher Type of Double Tube Tire Mounted on a Regular Clincher Rim.

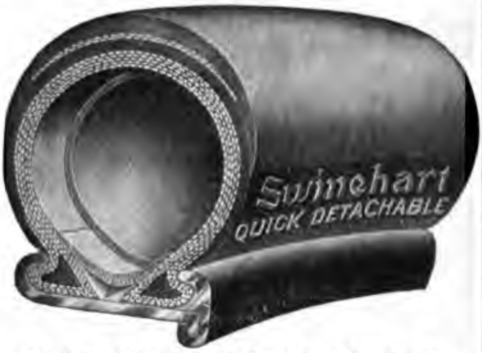


Fig. 2—A Pneumatic Clincher Type of Double Tube Tire Mounted on a Q. D. Rim, meaning a quick detachable type of rim.

Note the difference between the two above rims.

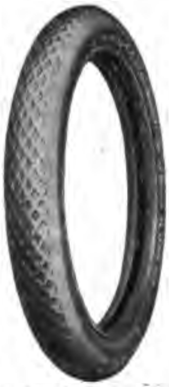


Fig. 3—A Pneumatic 'Non-Skid" Swinehart Type of Tire for either the Clincher or Q.D. Rim. This is a rubber tire of usual construction, but **with rubber ridges, crossing diagonally.**

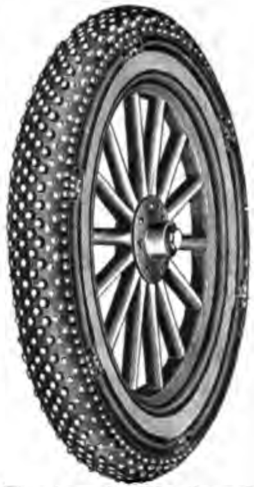


Fig. 4 — A Woodworth Tire Protector Tread. Is a leather covering or tread with steel rivets that pass through the tread. They are made to fit over the tires. They protect the **tires from wear and from punctures, cuts, bruises, etc., or other outside injuries, and as a non-skid, they are good for any surface except snow or ice.**

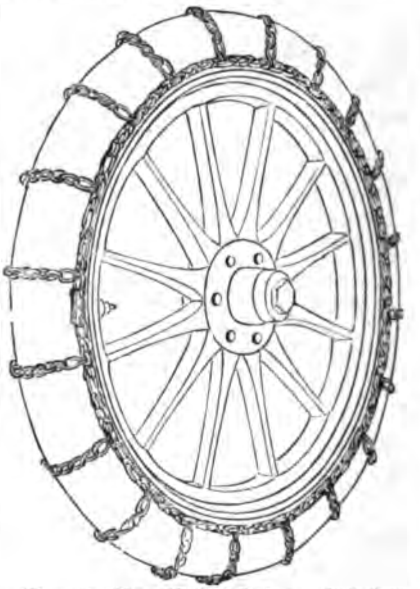


Fig. 5 - Non-Skid Chains. Suitable only for snow, ice and mud. The chains are placed over the tires.

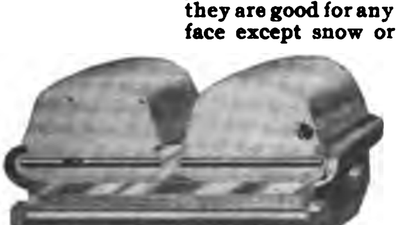


Fig.7—The Swinehart "Double" Solid Rubber Tires for heavy trucks.

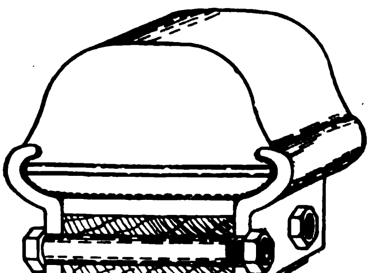


Fig. 6—The Swinehart "Single" Solid Rubber Tire for light trucks and deliveries.

Types of Tires in General Use

CHART No. 138

The Inner Tube Is an Endless Tube, (Chart 136, Fig. 4) fitting the interior of the shoe, and made of the best grade of soft rubber, that it may retain the air pumped into it.

THE VALVE.

The Only Opening Into the Inner Tube Is the Valve, through which the air is forced. (Fig. 4, Chart 136 and Fig. 1, Chart 137.)

The Inner Valve or Schrader Valve must sometimes be replaced with a new one. The small rubber washer "C"—Chart 137, Fig. 2—hardens and permits the air to pass out. Slow leaks are often the result of a leaking valve—"A."

The Valve Is Contained Within a Short Piece of Brass tubing, and consists of a small piece of leather or soft rubber that is drawn against the end of the brass tube by a coil spring. (Fig. 1, Chart 137.)

When Air Is Forced Into the Inner Tube, the valve (Fig. 2) opens and permits it to enter, and by closing prevents it from escaping.

Air Escapes From the Inner Tube Because of Valve Leaks, Punctures, Blowouts, or Porosity, the last being the effect of age, by which rubber hardens and cakes.

The Valve Stem, which is the tube containing the valve, is passed through a tough piece of rubber or fabric, called the VALVE BASE.

Lock Nuts J-H, on the Stem secure it firmly to the base.

The Valve Base is Firmly Cemented or Vulcanized to the inner tube, the valve stem passing through a hole in it.

Valve Leaks Are Due to the hardening of the leather or rubber valve, or to leakage between the tube and the base.

The Valve, Fig. 2, Is Screwed Into the Valve Stem, and can easily be removed for replacement.

A PUNCTURE.

A Puncture Is the Result of a hole being made in the inner tube by any sharp object passing through the shoe, or by a small stone or other hard object being left inside the shoe when the inner tube is applied.

A BLOWOUT.

A Blowout, which is the tearing open of the inner tube by the pressure of its air, is caused by the shoe being so worn that the fabric and rubber are no longer able to resist the pressure of the inner tube.

A Large Cut in the Shoe by a broken bottle or similar object may also cause a blowout.

CLINCHER AND QUICK DETACHABLE.

Double Tube Tires Are Divided Into Two Classes, CLINCHER, Fig. 1, Chart 138, and QUICK DETACHABLE, Chart 138, Fig. 2, both referring to the method of attaching the tire to the rim.

In Clincher Tires, the edges of the rim curl up, so that the bead of the tire must be stretched in order to get the shoe in position. (See Chart 136, Fig. 1—138.)

When the Shoe Is in Place, the air pressure is sufficient to hold it so that it cannot move, but for larger sizes, 2½ inches in diameter and over, lugs are necessary to prevent them from CREEPING.

By Creeping, it is meant that the tire moves around the rim, tearing the valve stem from the inner tube.

In Quick Detachable Tires, one side of the rim, forming one of the grooves, is detachable.

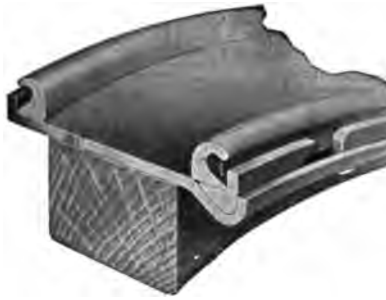


Fig. 1—The Standard Universal Quick Detachable Rim, Type 2

In this illustration the beads of rim are reversed to take a **straight side** tire. By reversing the beads the rim will then take a clincher tire.

This is the type of rim now adopted by a majority of manufacturers.

Note that a tire is easily placed on this rim. Merely loosen bolts, take off the side flange, remove the clincher bead and slip on the tire. This is why it derives its name; Quick Detachable; meaning the tire is quickly attached or detached.

Standard Universal Quick-Detachable Rim Type 2 is made to shrink permanently on the felloe of the wheel.

Both side rings are continuous, reversible and interchangeable to take ALL straight-side and clincher pneumatic tires.

The front side-ring is secured by means of an L-shaped split locking ring, which engages a groove in the rim base.

The spreader attached to the valve stem and which is a part of the inner tube, prevents the locking ring moving out of position when the tire is deflated.

To Detach: Remove dust cap from valve stem. Make sure tire is deflated. Place a screw driver under the beveled end of locking ring. Push the side-ring inwardly and at the same time lift end of locking-ring from its groove. Remove side-ring and tire is free.

To remove the tire after the side-ring has been taken off, turn the wheel so as to have the valve at the highest point, grasp the tire at the top with both hands and pull it forward as valve will allow, then by gradually working the hands down side of tire and exerting a pulling pressure it will slide from the rim at the bottom and the valve can be lifted free from the wheel.

To Replace the Tire reverse the above operation.

Old Style Clincher Rim

The old style clincher rim shown in fig. 1, chart 136. It is necessary to pry the tire on, over the clincher rim. Note that it is solid on both sides.

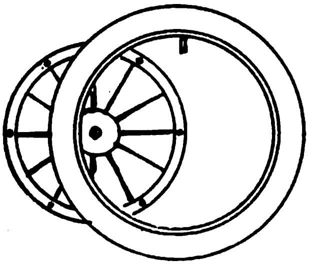


Fig. 2 Quick Detachable Demountable Rim

The tire is the usual Clincher tire, but is mounted on a steel rim which can be removed from the wheel, tire and rim together. Fig. 3 shows how a demountable rim carries a tire all inflated ready to attach.

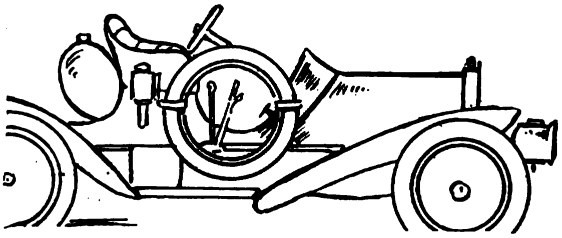


Fig. 3—Showing the Q. D. Demountable Tire Inflated on the Demountable Rim carried on the side of the car (or elsewhere) ready to put in the place of damaged tire. Note, this tire is inflated.

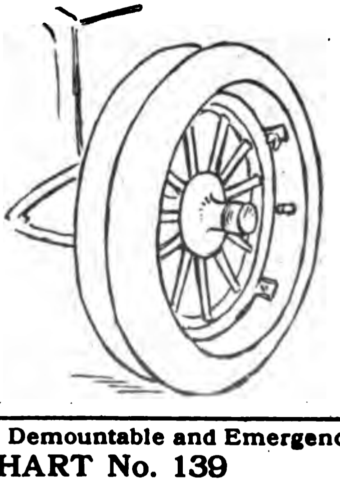


Fig. 4 — An Emergency Tire and Rim is a type of tire usually carried inflated on a special rim which can be bolted or clamped to the side of the damaged tire. The damaged tire is not removed until destination is reached.

Quick Detachable, Demountable and Emergency Rim

CHART No. 139

The Standard Universal Quick Detachable Demountable Rim No. 2

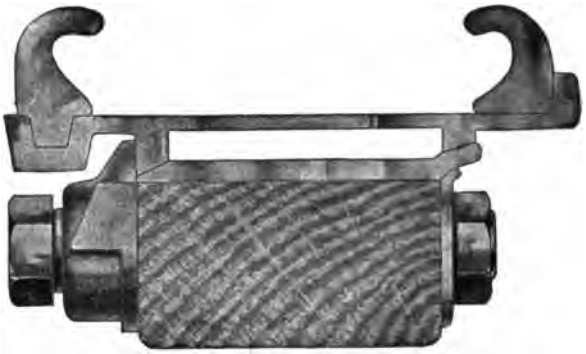


Fig. 1—The New Q. D. Demountable Rim Type 2 Showing clamp unlocked. By reversing rims it will take a Dunlop or straight side tire.

The rim illustrated herewith is the very latest development along the line of Quick Detachable and Demountable equipment. The tire rim still affords the excellent advantages of the No. 2 Standard Universal Quick Detachable Rim: reversible side rings (shown above in position for accepting straight side or Dunlop Type Tires) and safe and sure seating of side ring over locking ring which prevents displacement of locking ring. The Demountable Device has been improved upon, and you will now notice the absence of clamping ring or wedges.

This is the rim which will be used in the future on all Standard Cars.

Standard Universal Quick-Detachable-Demountable Rims Type 2 consist generally of the rim body, the felloe band and the securing device. These rims are detachable, independent of their demountable features.

The Quick-Detachable parts and their operation are identical with those shown and described in Chart 139.

The demountable type felloe band, which is shrunk permanently on the felloe, has at each outer edge a concentric cone section or frustrum which gives continuous circumferential support to similar cone frustrums on the inner surface of the rim body.

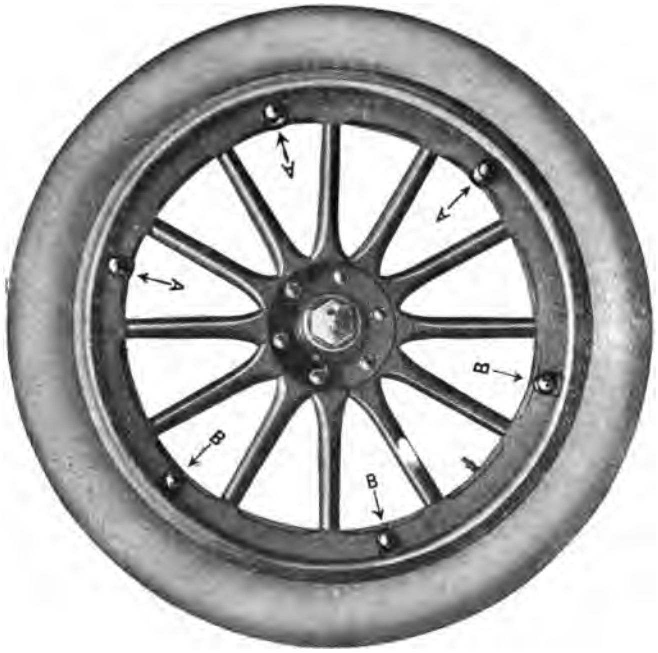


Fig. 2—Wheel Fitted with Standard Universal Quick-Detachable-DEMOUNTABLE Rim with Clamp Lock, Showing Three Clamps Unlockod (A) and Three Locked in Position (B.)

The securing device consists of six rotary clamps so designed that two turns of each clamp nut automatically forces the rim home, centers it laterally and concentrically on the felloe and permanently locks it in position. Two back turns of the clamp nuts free the rim for demounting.

Each of the six locking clamps is secured by a bolt which extends through the felloe.

The back nut and washer engage the inner edge of the felloe band, giving it lateral support.

The New Type 2 Quick Detachable Demountable Rim. The Rim Which Will Be Universally Used

CHART No. 139A

THE STANDARD UNIVERSAL QUICK DETACHABLE RIM.

Represents New and Distinctive Ideas of rim construction. This type of rim will be universal type of rim of the future. (See Chart 139.)

There Are Many Good Features (represented) in this style over the old style Clincher rim tire.

1st. EASE OF ATTACHING AND DETACHING.

2nd. TIRE AND RIM CAN BE REMOVED WITHOUT DEFLATING TIRE.

3rd. A SPARE TIRE, INFLATED AND MOUNTED ON THE RIM, MAY BE CARRIED ON THE SIDE OF THE CAR AND ATTACHED OR DETACHED IN A FEW MOMENTS.

The Chart will give you a clear idea of this rim.

THE QUICK DETACHABLE DEMOUNTABLE RIM.

Is Illustrated and Explained in Chart 139 and 139A.

THE EMERGENCY RIM AND TIRE.

Is Illustrated and Explained in Chart 139.

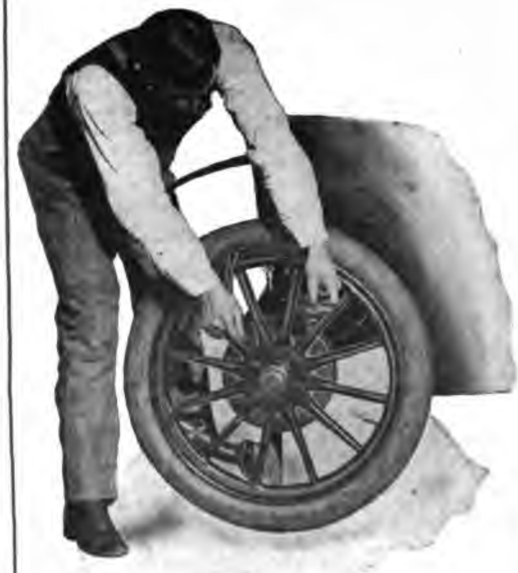


Illustration No. 1
Inserting Levers Under Edge of Outer Case. Tire of course is deflated.—(detaching.)

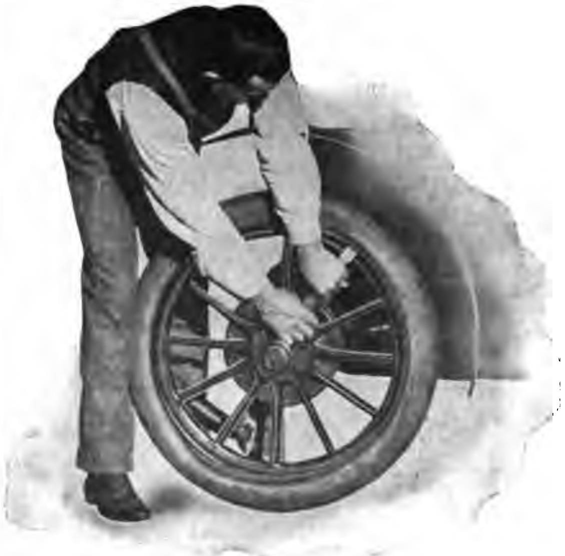


Illustration No. 2
Prying off Outer Bead of Tire by pushing the tool around the wheel, thereby prying off the outer bead of tire. Inner tube is usually removed when outer bead of case is free from rim,—(detaching.)

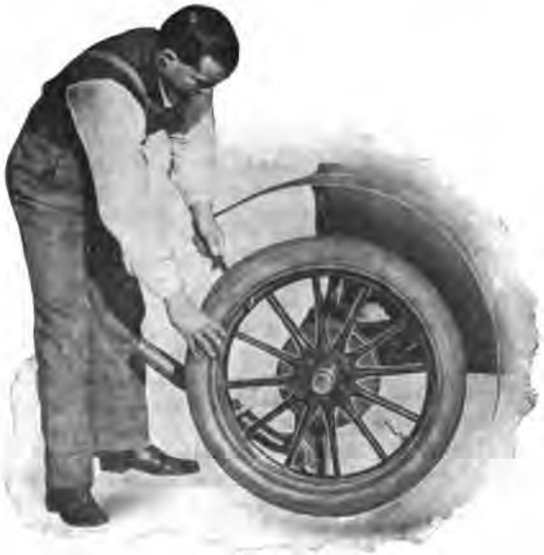


Illustration No. 3
Taking off Inside Bead of Tire after outer bead is free from rim.—(detaching.)

Detaching a Regular Clincher Tire
CHART No. 141

THE PUTTING ON AND TAKING OFF OF TIRES. ON ONE-PIECE CLINCHER RIMS.

The Instructions in This Chapter For the Putting On or Taking Off Tires apply entirely to the use of tires on ONE-PIECE CLINCHER RIMS.

Regardless of the Style of Lever Used with tires on one-piece rims, operation is in general the same in any case. The only difference is that some levers permit of more rapid progress and the exertion of less muscle than others.

Experience Offers the Most Valuable Lesson in the removing and attaching of tires and it is a good plan to familiarize yourself with the process, at some convenient time.

In the Accompanying Illustrations the operator is shown using the large and small plain levers. (See Chart 140, on page 388.)

HOW TO REMOVE A CLINCHER TIRE.

Jack Up the Wheel so that when inflated the tire will be clear of the ground.

Thoroughly Deflate the Tire by removing the cap from the valve stem and inserting the notched end in the valve. The plunger being unscrewed and removed allows the air free passage.

Remove the Nut and Washer From the Valve Stem and as the air escapes put them with the cap and plunger in a safe place until again needed.

Loosen All the Staybolts of the tire until the nuts are held by just a few threads and push the bolts up through the rim into the tire. If they stick or are hard to move, they may be pounded gently, but care must be taken not to damage the threads. Turn the wheel until one of the staybolts it at about the center of the upper circumference, brace it, press the staybolt up into the tire.

This Releases the Bead of the Tire at this point enough that by pressing with the left hand and a small lever held in the right hand against the wall of the tire, the lever can be inserted beneath the bead. (See Chart 141.) Leaving the lever in this position, similarly insert a second lever beneath the bead at the opposite side of the staybolt and two or three inches from it. Holding a lever in each hand, press down (see illustration No. 1) and the bead is pried safely over the rim at this point. With the use of a large lever it is now a simple matter to pry the outer edge of the casing out of the rim all around the wheel (see illustration No. 2).

With an Old Tire It Will Probably Be Found that it is inclined to stick to the rim. Sufficient pressure or a sharp push will release it.

As Each Staybolt Is Reached, as the operation of removing the outerbead proceeds, see that the bolt is pushed into the casing so that the bead may slip from beneath it. Care should be used, also, that the inner tube may not be damaged by the lever.

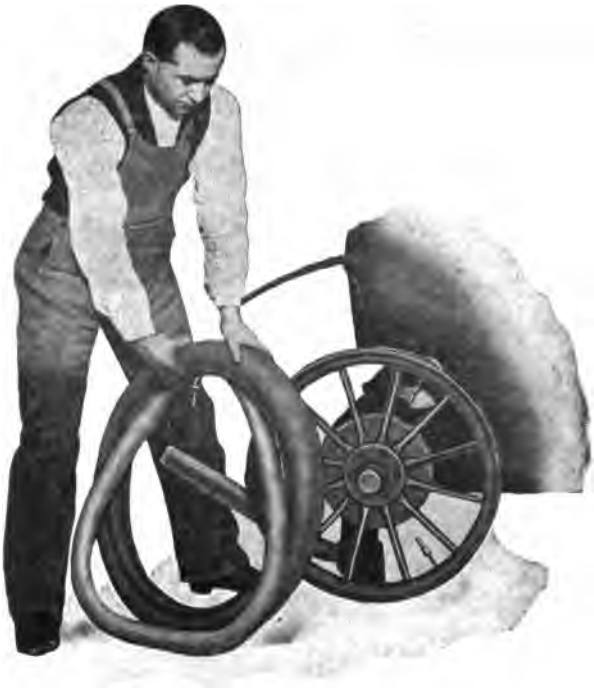


Illustration No. 1
Placing Inner Tube in Case, slightly inflated. After tube is placed inside of case, the case is then placed over rim and inside bead is easily placed under rim.

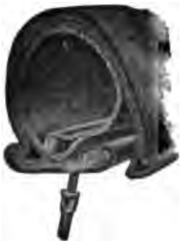


Illustration No. 2
Staybolt must be passed into the tire, both beads can be placed under it, also to get tube out of harm's way.

Illustration No. 3
Showing how tube is sometimes pinched by rim or beads.

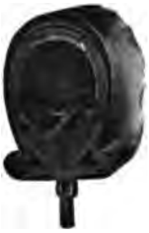


Illustration No. 4
Showing how a tube is sometimes pinched by staybolt or lug.

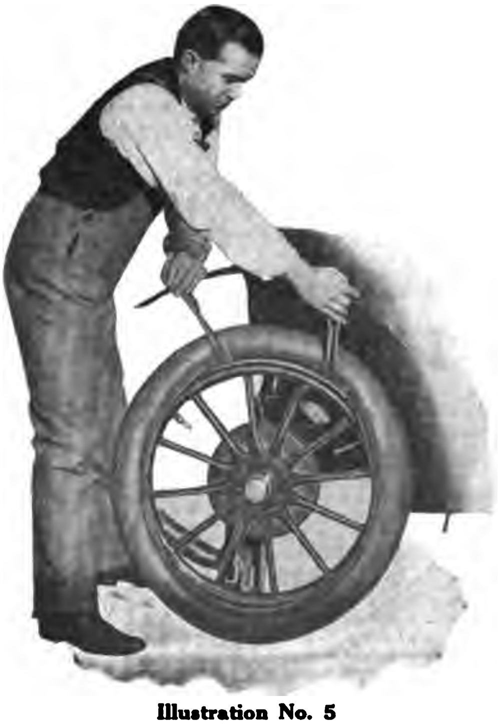


Illustration No. 5
Placing the Outer Edge of Casing Into Rim.

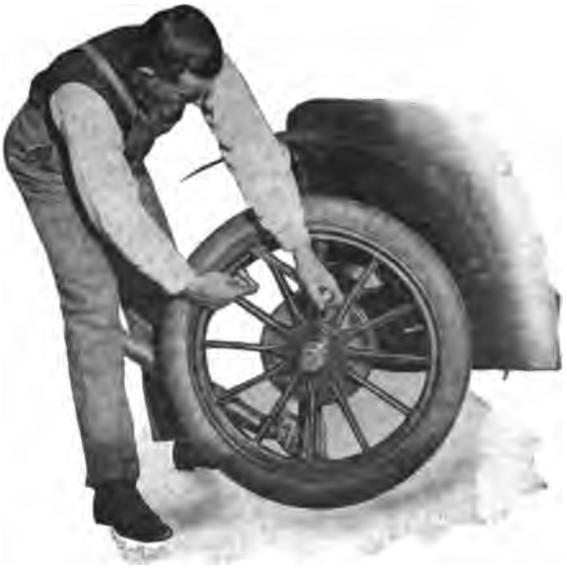


Illustration No. 6
Push the staybolt into the tire. If it works free then it is ready to be tightened. The picture shows the tire completely in place and tool ready to be removed and tire blown up.

Attaching a Clincher Tire and Inserting Tube
CHART No. 142

When the Outer Edge of the Casing Is Free, reach under it and push the valve stem of the tube through and out of the rim into the casing. Then, beginning at the valve and going slowly, lest damage result, remove the inner tube from the casing. If it sticks it should be worked loose with the fingers or pulled easily. Being of pure rubber, it is possible to tear it.

To Remove the Tire Entirely, now insert a lever at the opposite side of the wheel, pressing it beneath the tire and resting the point of the lever upon the outside edge of the rim (illustration No. 3).

By Working the Lever Around the Wheel the tire is taken off. As each staybolt is reached, the bead must be released by pushing the bolt up into the casing, or the bolt may be taken out.

Working Inner Edge of Casing Over Outer Edge of Rim.

It Is Not Necessary to Remove the Staybolts From the Rim, as they should be attached and hanging loosely with a few threads caught within the nuts as you make ready to put a tire on, and yet by some operators it is considered best to take the bolts out of the rim before undertaking to release the inner edge of the tire. Much will depend on individual experience with respect to this and similar matters.

HOW TO APPLY REGULAR CLINCHER TIRES.

Sprinkle Powdered Soapstone or Talcum Freely in the Interior of the Tire Casing. Use plenty of it, but not enough to allow it to collect and form lumps.

The Inner Tube Should Be Inflated Just Enough to Make It Rounding and also liberally coated with talcum and then placed inside the casing. (See illustration No. 1, Chart 142.)

The Powder Acts as a Lubricant and allows the tube readily to adjust itself without puckering or creasing, and also helps prevent the twisting of the tube which should be carefully avoided.

Insert the Staybolt in the Holes in the Rim (if they are not already in place), taking care not to get a staybolt into the larger hole intended for the valve stem.

Attach the Nuts to the Staybolts Just Sufficiently That the Bolts Cannot Drop Out as the wheel is revolved.

Placing the Tire Over and Partially Around the Wheel, insert the valve stem in the rim. Fasten the lock-nut upon the end of the valve stem so that this is held loosely in place the same as the staybolts.

ATTACH INNER PART OF CASE, NEXT TO CAR, FIRST.

With the Levers Force the Bead on That Side of the Tire Nearest the Car Into Position Within the Rim, allowing the bead on the side nearest you to overlap the rim.

As the Bead at the Inner Side Is Adjusted Push the Staybolts Upward through the rim, as each in turn is reached (see illustration No. 2, Chart 142), in order that the staybolt heads shall come above the bead and also to raise the tube up so that it will not be caught between the rim and bead, as shown in illustration No. 3. Great care must be taken, also, to avoid the tube beneath staybolts as shown in illustration No. 4. This is important.

The Task of Forcing the Bead on That Side of the Tire Nearest the Car Into the Hook of the Rim Is Not Difficult, especially with an old tire.

It Will Be Necessary, however, to pry it over the last two or three staybolts.

To Do This Insert a Lever From the Side of the Wheel Nearest the Car and placing the point of the lever under the inside bead of the casing, and using the inside edge of the rim as a fulcrum, bear down on the lever.

This Will Lift the Bead Up and Over the Staybolt adjacent to which the lever is inserted.

In Attaching Both the Inside and the Outside of the Tire care should be taken not to allow the tire to bulge or pucker in one place or stretch too much in another.

In This Condition it cannot seat itself securely.

Remember That Tube Pinching Will Most Certainly Cause Trouble; not at once, perhaps, but in a short time.

Many a Good Tire Has Been Declared Faulty because the tube was pinched.

It Is Possible, Also, to Pinch a Tube Between Rim and Valve Stem, but if care is used this will hardly happen.

It Is a Wise Plan to Insert the Hand Beneath the Free Outer Edge of the Tire and by feeling within ascertain that the tube is no place caught. Be careful always not to damage the tube by rough handling of the tire levers.

TO ATTACH THE OUTER BEAD.

By Use of the Levers as Shown in Illustration No. 5, beginning at the valve, the outer bead can be sprung and pressed into position.

When the Inner Edge has been attached be sure that each staybolt is pushed into the tire so that the bead can slip under it, and the same care as before must be taken to avoid catching the tube beneath bead or staybolts.

A Rim Pinch is most likely to occur near the staybolts, or the valve, or at that part of the casing which is applied last.

When a Small Part of the Outer Bead Has Been Sprung Into the Hook of the Rim the remaining position is easily attached.

With the Lever It Is Forced Into Place by running the lever slowly around the rim, a little distance at a time, with the revolving cone of the lever pressed against the rubber.

With an Ordinary Lever the bead must be pried into place, a short distance at a time.

Muscle Must Be Used to lift the last portion of the bead over the edge of the rim and into place, especially with a new tire.

Don't Hesitate to stretch the edge of the tire.

It Is Necessary.

Note Particularly, that as the outer edge of the tire is worked into place, the same care as in attaching the inner edge must be exercised to see that the staybolts are pushed up, as each in turn is reached, to allow the bead to slip beneath them. (See illustration No. 6, Chart 142.)

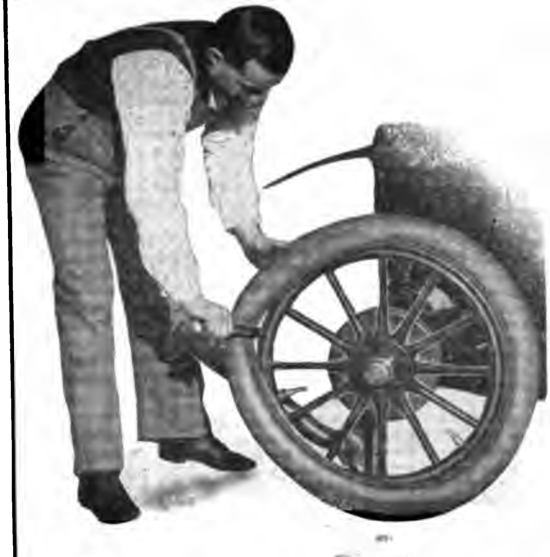


Illustration No. 1

Lever under both sides of casing, preparatory to insertion of valve stem. The inner tube is usually inserted when the inside of bead is placed under the inner side of rim.

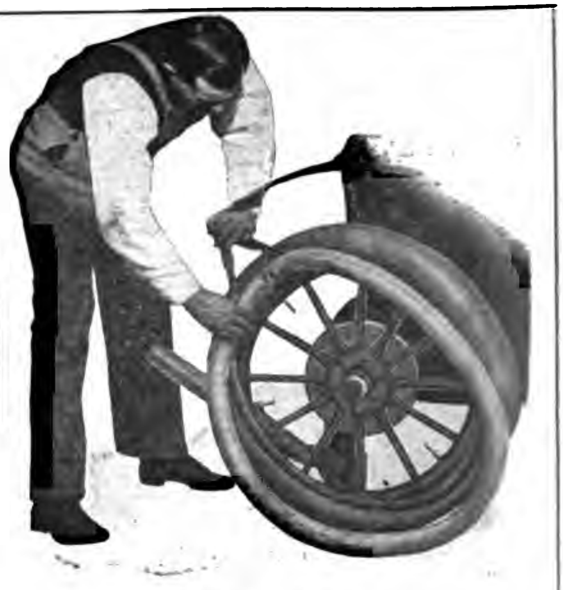
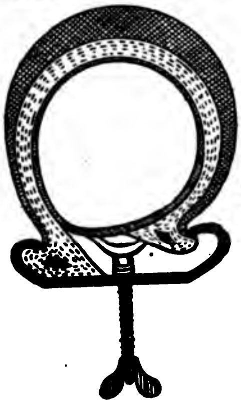
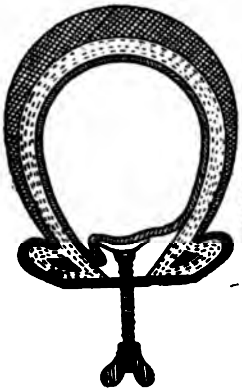


Illustration No. 2

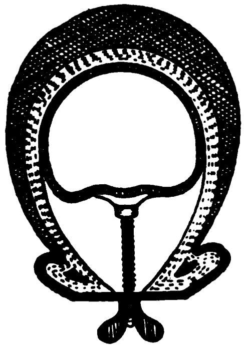
Inserting the valve stem in rim. Then tube is placed inside case; then outer bead of tire is placed under outer bead of rim.



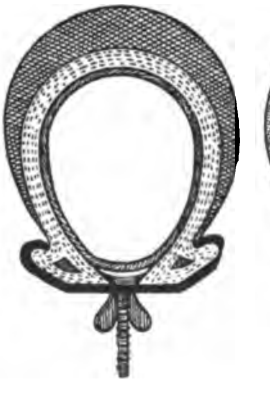
Illustrating a possible fault in attaching. A security bolt preventing the edge of cover going into its position. The bolt must be manipulated into its correct position so as to allow the beading to slip into its place.



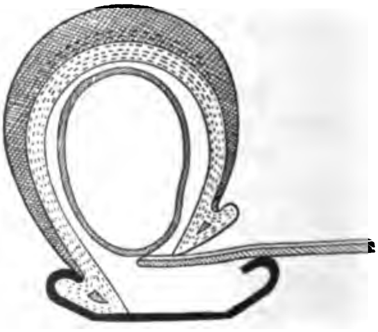
Illustrating a serious fault. The inner tube has become nipped between one of the security bolts and the cover, and unless released will certainly result in a burst tube.



Illustrating how the security bolts, by being pushed towards inside of tire before screwing down, allow cover and tube to fit into the correct position. The ordinary security bolt has a canvas-covered head which sometimes causes air-tube defects such as nipping and chafing. If bolts with moulded rubber heads be used these defects are not likely to occur.



Illustrating the tire properly fitted up, the security bolts in place, and inner tube snug in its place, no nipping at any part. The tube when pumped up should be even all the way round the rim, and run truly when the wheel is rotated.



When raising the cover over the edge of the rim with lever, special care must be taken not to pinch the air tube between rim and lever. This would result in damage to the tube, rendering it useless till repaired.

Inserting the Inner Tube and Faults Likely to Occur

CHART No. 143

Make Certain, Also, that in no instance is the head of a staybolt turned crosswise of the tire.

When the Tire Is in Place, nuts on staybolts and valve stem should be tightened. As this Work proceeds, again push each staybolt upward into the tire (see illustration No. 2, Chart 142). If the tube is caught between the bead and rim, resistance to moving the staybolt will be noticed, and the tube must be released from the pinch.

If the Staybolts Move Upward Readily It Is Reasonably Certain That the Tube Is Out of Harm's Way.

When the Nuts on Staybolts and Valve Stem Have Been Tightened, inflate the tire so that it stands up round under the full load, then screw the nuts up very tight. If a new tire has been put on it will probably be necessary to add more air after a few days of use—and still more a week or so later.

In keeping staybolts tight do not neglect, also, to keep the valve stem nut tight, as water can get into the tire here as well as at the staybolts.

HOW TO INSERT A TUBE.

It Is Generally True in Case of a Tire Being Punctured, that the user will wish to insert a sound tube and mend the punctured one more conveniently at the end of his trip.

In Using the Quick Detachable Tires it is best to take the tire entirely off the wheel, and so remove the damaged tube.

With One-Piece Clincher Rims, However, it is not desirable to do so.

Simply Jack Up the Wheel and Detach the Outer Edge of the Casing.

With the Outside Bead Free From the Rim, reach under and into the casing and draw the valve of the tube out of the rim and then withdraw the tube from the casing.

If It Sticks in the Casing, work the fingers beneath it and pull slowly lest damage be done.

Make Certain that the nail or other cause of the puncture is removed from the casing or tube or both and then insert a sound tube.

To Do This, without removing more than the outer edge of the tire from the rim, the principal task is to insert the valve stem in the hole in the rim designed for it.

Introduce a Lever Beneath Both Sides of the Casing two or three inches to the right of the valve stem hole, so that its point rests on the outer edge of the rim nearest the car. (See illustration No. 1, Chart 143.)

Holding the Lever Thus, similarly insert the second lever two or three inches to the left of the valve stem hole.

Now by Pulling Both Levers With the Left Hand the tire can be lifted up and toward the car sufficiently to allow the valve stem of the tube to be put in place. (See illustration No. 2, Chart 143.)

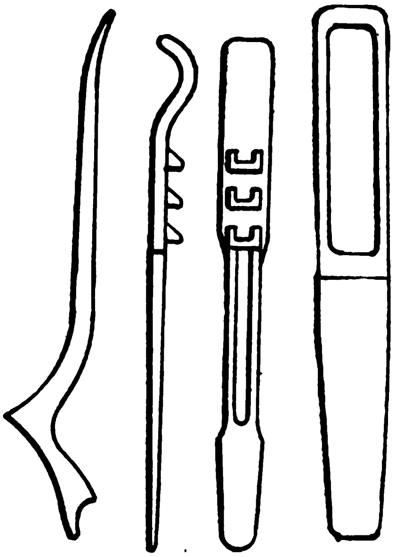


Fig. 1—Shows a Set of Tire Tools suitable for attaching and detaching clincher tires on one-piece rims.

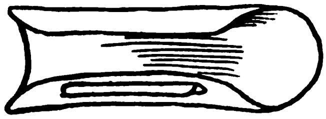


Fig. 2—An Inside Blow-Out Patch. Very useful. Intended to be placed inside of a tire cover or case when tire is cut through the fabric. These patches can be had of any Supply House or can be made of an old case by peeling the rubber off.

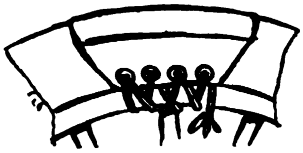


Fig. 3—An Outside Blow-Out Patch. Intended to be placed on the outside of a tire when cut or damaged.

Fig. 4 - When Repairing an Inner Tube, carefully examine the tube all over. You may find one hole and mend it, yet there may be another. It is advisable to always carry an extra inner tube while on the road and in case of a puncture or blow out, put in the new tube and have the old tube vulcanized.

Fig. 3 - When Repairing an Outer Case which is blown through or cut, it is advisable to immediately place an inside patch (fig. 2) inside of the case and after tire is placed back on rim and partly inflated then put over the damaged place the outside patch (fig. 3), lace it in place, then inflate tire fully. This will protect the tire until it can be repaired.

Tire Tools and Repairs

CHART No. 140

INSTRUCTION No. 32

REPAIRING TIRES:—Temporary Repairs. Cause of Blow-Outs. Inner Tube Repairs. Care of Tires. Proper Inflation of Tires.

Repairs are most effective when made in good season, what to do and how to do it. Regardless of the style or type of pneumatic tire employed, the attention it should receive at the hands of the user to prevent and repair damages, is substantially the same. Whether the tire be of one make or another, is also immaterial. It is important that the rim shall be correct and true.

There Are Few Forms of Injury to Tires Which Cannot Be Temporarily Repaired. He should not, however, consider as permanent the repairs he may himself make.

It Is Always Preferable to Send Tires to the Repairer For the Making of Permanent Repairs.

But Even the Tire Repairer Is Not Always Able to Make a Repair Which Would Justify the Expense of Undertaking it. This is in most cases due to the neglect of the tire user. The casing has been allowed to run too long in a damaged condition, it may be. Perhaps it has been cut through by the rims, due to running "flat." If it is a tube which is beyond repair, its condition is most probably due to similar cause or rough handling.

When the Tire Becomes So Worn That the Fabric Shows Upon the Tread it is high time it were sent to one of the repair stations. A new tread can be applied without injury to the body of the tire and the whole made almost literally as good as new if the worn casing is sent to us in good season.

INCREASED SERVICE BY TRANSPOSING TIRES.

In Ordinary Wear it is usually true that tires on the right side become worn more quickly than those on the left. This is due to their being run into ruts and stones, when the car is turned out of the traveled roadway, and because the tires of the right side suffer most from curbings and the like as the driver uses the right side of the street.

Ruts, Curbings and Similar Tire Destroyers May Wear the Outer Wall of a Casing nearly to the fabric, but if the tire is reversed, and that side which has been exposed and most worn placed nearest the car, it will still be serviceable.

As the Rear Tires Sustain More Than Half the Burden in every movement of the car they will wear more rapidly than the front tires. For this reason it is not infrequently advisable to change the rear tires to the front and vice versa.

TEMPORARY REPAIR OF CASING.

If a Hole Larger Than a Small Nail has been made in the casing, a temporary repair should be made.

The Operation Is Simple, with the tire removed from the wheel, wash with a very little gasoline the dust and grime from the interior of the casing at the spot to be repaired, and cement over the puncture inside the casing a patch of heavy fabric, such as is furnished with all repair kits.

It Is Well to Force a Little Cement into the puncture from the thread side of the tire.

Allow the Cement on the Patch Ample Time to Dry, sprinkle some talcum over the spot repaired, and the work is done, providing the puncture is not a large one.

If a Considerable Break or Cut Has Been Made in the Casing it Will Be Advisable Also to Provide a Repair Bandage. (See Chart 140). Otherwise the patch may not prevent the blowing out of a tube. and, moreover, sand and dirt would work into the casing in such quantities as to be likely to cause a sand blister and possibly a separation of the plies of fabric, while moisture would also rot them.

In Case the Cut or Puncture of the Casing Is Large Enough to Admit a Finger, or nearly so, a rawhide instead of a fabric patch should be applied to the interior.

Every User of an Automobile Should Carry One or More Repair Bandages. To apply the bandage buckle one end around a spoke, then wrap the bandage securely around the deflated tire letting it overlap itself scale fashion each time the tire is encircled. Buckle the loose end tightly to another spoke. When the tire is inflated the bandage will be securely held in place.

As Has Been Previously Pointed Out, the object in at once temporarily repairing casings which have been badly punctured, or otherwise cut, is to keep moisture and dirt from working into the fabric, as well as to prevent the inner tubes from blowing out. Only a vulcanized repair can do this permanently.

To Avoid Being Without the Use of Your Car While Tires Are Out of Service for any reason, it is always desirable to have on hand at least one or two extra casings and tubes. On long tours it is wisdom to carry an extra casing and a couple of tubes with you.

If All the Plies of Fabric Have Been Cut Through by the Rims It Is Usually Useless for anyone to attempt to make a repair. If the casing is cut through all around it is ruined.

The Time to Act Is at the First Sign of the Casing Being Cut. A blowout of the tube will occur sooner or later, otherwise.

In a Case of Great Necessity, a tire which has been cut entirely through or blown out at the rim, may sometimes be fixed up to enable the user to travel some distance by applying one or more repair bandages.

If the Cut Is a Wide One a single bandage will hardly be sufficient.

The Tire Should Be Fully Two-Thirds Deflated and the bandages wrapped exceedingly tight and fastened very securely.

Then Inflate the Tire, as usual, but it will be wise to run at moderate speed, with the tire in this condition.

Note Particularly That the Course Above Described Should Not Be Resorted to Except From Extreme Necessity. The great danger that good tubes will be spoiled in the endeavor to use the worthless casing makes the practice unwise, except in emergency.

It Will Be Observed That Rim Cutting Is Almost the Worst Damage a Tire May Suffer. So remember that irregularities in the rims will cut or damage tires and attention is again called to the necessity of using inspected rims. These rims always bear the inspector's mark and clincher tires are guaranteed only when used on rims so branded.

CAUSES OF BLOW-OUTS.

In General, if tires are kept properly inflated, used in proper sizes and on proper rims, there are but three common kinds of injury which they are likely to suffer, in addition to natural wear. The extent of the latter, of course, depends on conditions of service.

First of These Three, and perhaps the most dangerous, as it is the most difficult to discover, is the "stone bruise."

This Consists of an Internal Injury to the casing, due to a violent collision with the street curbing or some other obstruction.

One of the Plies of Fabric in the Casing Are Broken and a weak spot is the result.

The Strain of Service Is Largely Centered in This Spot, for the reason that any article will give most at its weakest point.

In Time a Blow-Out Occurs, it may happen on a perfectly smooth road.

The Tire User in Many Cases considers the accident capable of only one explanation, and that is that the tire was defective.

Unfortunately, a stone bruise does not show itself either inside or outside the tire casing.

If There Is Reason to Believe that a casing has been bruised sufficiently to rupture a ply of fabric, it is wise to remove the tire and examine it.

The Weak Spot, if one exists, is usually apparent **by the unnaturally easy bending of the casing at the damaged spot.**

The Inserting of a New Section at This Point, a repair which requires the most expert handling, is the only remedy.

But by Having Such a Repair Made, one will save himself from an accident when he may be miles from home, and also save the inner tube from damage.

A "Jab" or Deep Cut, or it may be a severe puncture, is most likely to be followed by a blow-out in just such a manner as that which a stone bruise produces if a repair is not made.

In the Case of a Cut or Bad Puncture, however, the danger is increased because moisture is admitted to the fabric.

A Vulcanized Repair Is the Remedy, and deep cuts and punctures reveal themselves if the tire is carefully examined, it is usually possible to repair the damage and eliminate the danger.

Still Another Form of Blow-Out is due to excessive wear of the tire or deterioration of its strength, due to long service.

Or It Is Possible that a defect in the casing itself may be responsible.

An Injury of This Kind may be called a "Clean blow-out," and it may be guarded against by having the tires **retreaded in reasonable season and keeping them in repair generally.**

INNER TUBE REPAIRS.

Punctures. Although it is not uncommon for automobile owners to travel thousands of miles without any puncture of their tires, there is no getting away from the fact that such an injury is likely to be sustained at any time. Preventives are all too apt to defeat the very purposes of the cushion of compressed air and almost without exception should be avoided. To repair a puncture, however, is a simple matter.

Tube Pinching. Returning to the most common causes of damage to inner tubes, attention is called to the manner of repairing tubes that have been pinched beneath the bead of the tire or beneath the staybolts.

Proceed in the Same Manner as You Would to Patch a Punctured Tube, but as the incision in the tube may be a large one, take care to use a patch which will not only cover, but overlap, the damaged spot by a comfortable margin on all sides.

The Valve May Leak. It sometimes happens that a tire becomes deflated because of a leaking valve, and the condition may easily be supposed to be due to a puncture. If no visible sign that the tire has been penetrated is discovered, put a few drops of water in the valve stem. Bubbles will indicate a leak.

If Such Is the Case the Valve Parts Should Be Tightened With the Notched Cap of the Valve Stem inserted in the valve and used as a wrench.

If This Does Not Remedy the Trouble, new valve parts should be put in place.

Every Repair Kit Is Supplied With Them and they should be kept in the kit constantly.

METHOD OF REPAIRING INNER TUBE.

In This Case the Inner Tube Is Supposed to Be Punctured, but the casing practically uninjured, as in the case of puncture by a pin or nail.

First of All Satisfy Yourself That the Pin or Nail Is Not Sticking in the Casing, for if it is, your repaired tube will be punctured again before you have gone 1,000 feet.

Having Done This, the inner tube may be removed (wholly or in part, as may be necessary) and either repaired or replaced.

When on the Road It Is Much Simpler to Put In a New Tube; and it is best to have always at hand three spare tubes—one for the forward and two for the rear tires.

An Inner Tube Properly Repaired Is as Good as New, but it is much easier to make the repair at home.

Do Not Carry These Tubes in the Tool Box where they are liable to be bruised or otherwise injured.

To Proceed, the injured portion of the tube being laid bare, proceed LEISURELY as follows:

Select a Patch of the Right Size; that is, large enough to extend 3-4 of an inch or an inch beyond the puncture in each direction. Wipe off every trace of moisture or bloom and roughen with emery cloth the surfaces to be joined. Apply two coats of cement to the tube surface and to the patch, removing with the fingers all superfluous cement; the less of it there is, the more quickly the repair will be accomplished.

Allow the Cement to Dry until it adheres strongly to the fingers (five minutes at least will be needed), then, and not until then, apply the patch; compress strongly and look carefully to see that the edges of the patch do not loosen.

Before Putting Back the Tire, assure yourself that the part of the tube opposite the puncture (that is, next to the rim) has not been punctured also. It often is when the puncture is caused by a long pin or nail.

Note.—Never Try to Join Two Surfaces While They Are Still Damp, for rubber cement joints are of no value unless everything is dry. Never apply friction fabric to an inner tube, but always a patch of pure caoutchouc. Friction fabric is not airtight.

Even Though a Sound Tube has been inserted on the road, the punctured tube should be mended promptly to be ready for another emergency. There is scarcely a limit to the number of repairs a tube will bear, but patches applied with cement cannot safely be considered permanent repairs. It is a paying investment to have vulcanized repairs made as opportunities present themselves.

When a Patch Becomes Loose. It will sometimes happen that a tire will become partially or even entirely deflated without apparent cause—that is, without any nail or other puncturing instrument being visible. If you have had experience with occurrences of the kind, you will immediately suspect a loosened patch and proceed to verify your suspicions. Partly inflate the tire and your ear will tell you whereabouts the leak is. Only remove as much of the cover as will enable you to conveniently attack the job. You will very likely find that, although the air has burrowed a small channel between the patch and the tube in one place, other portions of the patch are holding on tenaciously. Why they do not stick all over alike is what no one ever could understand.

A Drop of Gasoline Applied With Care Does Wonders in Persuading the Patch to Peel Off, and afterward in cleaning the surface of the tube; but do not apply the solution until you have well roughened the place with sandpaper. Put the old patch away for future use, and apply a fresh patch, two coats of solution, spread on thinly, and well rubbed in, especially the first (you cannot rub the second coat hard, or the lot peels off); squeeze the patch and tube together as hard as possible with finger and thumb, beginning in the center of the patch and working out to the edges. You may hold a block of wood under the tube and beat the patch with a hammer if preferred, but go gently. One motorist belabors his patches unmercifully, and says they never come off. Judicious beating does no harm, and screwing up in the vise between two pieces of wood, and leaving all night, also works wonders.

RUSTY RIMS.

If There Is Anything That Causes Terror on the Part of the Automobile Man It Is Rust Caused by Water Getting Over the Edges or Through the Lug Holes Into the Interior of the Wheel Rims. Great care should be taken in washing wheels, to have the tires fully inflated and the valve and thumb nuts properly tightened. Tires sweat and gather dampness and this also causes rust.

To Prevent This, paint the rims with white lead. Last year I purchased a small can of white lead for 10 cents, mixed part of it with linseed oil and turpentine, cleaned and sandpapered the rims nicely, gave them a coat of paint and let them stand 3 or 4 days until thoroughly dry before puting on the tires. I examined one of the wheels this spring, after it had been used all winter, and found not a particle of color or stain on the tire. The paint is as hard as enamel.

A Rusty Rim Is Responsible for the Rotting of the Canvas and it is also the cause of cutting the edges. I have seen tires rusted to the rims so that they could only be removed with a hammer and tire iron. The best remedy is to paint the rims. Shellac will not do, as it flakes and peels off.

PROPER INFLATION OF TIRES AND WEIGHTS PER WHEEL WHICH DIFFERENT SIZES ARE MADE TO CARRY.

A Tire Is Not Inflated Enough if it does not stand up round under a loaded car.

Too Often Tires Are Allowed to Run in Such a Condition That They Flatten Under the Load. The effect is constant contraction and expansion of the tread of the tire and a constant bending of the walls, neither of which occurs to any considerable extent when the tire is pumped up hard. Moreover, a tire run partially flat is constantly bunching up a fold of rubber and fabric, which a laxity of pressure from within produces, just ahead of the point of contact with the ground.

SIZE TIRE	POUND LOAD 200	300	400	500	600	700	800	900	1000	1100
	POUND PRESSURE INFLATION									
3 Inch	45	55	65							
3½ "		50	60	70	80					
4 "				65	75	85	95	105		
4½ "					70	80	90	100	110	
5 "						75	85	95	105	115

We Give Below a Table of the Weights Per Wheel Which Tires of Given Sizes Are Guaranteed to Carry. Attention is particularly called to the fact that these weights represent the empty cars and do not include the added weight of passengers and baggage, for the normal extent of which weight allowance is made by the tire manufacturers in preparing this table.

THE SIZES OF TIRES FOR DIFFERENT WEIGHTS.

The table below is a list of weights, without passengers or baggage, which tires of our manufacture, of the different sizes, are guaranteed to carry:

Size	Weight per Wheel	Size	Weight per Wheel
28 to 36x2½	225 lbs.	28 to 36x3	350 lbs.
28x3½	400 "	30x3½	450 "
32x3½	550 "	30x4	550 "
34 and 36x3½	600 "	34x4	700 "
32x4	650 "	32x4½	700 "
36x4	750 "	36x4½	1000 "
34x4½	900 "		

For weights exceeding 1,000 lbs. per wheel, 5 inch tires and over are recommended.

POINTERS ON CARE OF TIRES.

Running a Tire Flat, even a short distance, is sure to be costly.

Better Run on the Rim, very slowly and carefully, if imperatively necessary, and the distance is very short, than on a flat tire.

Keep Grease and Oil Away from your tires and tubes always. They destroy rubber.

Keep Rims in Good Order, straight and true. Rust is destructive. Paint preserves.

Speedy Deflation demands instant attention.

Don't Let Weight Rest on deflated tires even over night.

If Your Wheels Are Out of True, their want of parallelism will have a bad effect on the tire covers.

Side Skidding and rounding corners rapidly will cause rim cutting.

Avoid Running in the street car tracks. It is very detrimental to the tires.

Do Not Drive in the ruts or bump the side of the tires against the curbing or pavements.

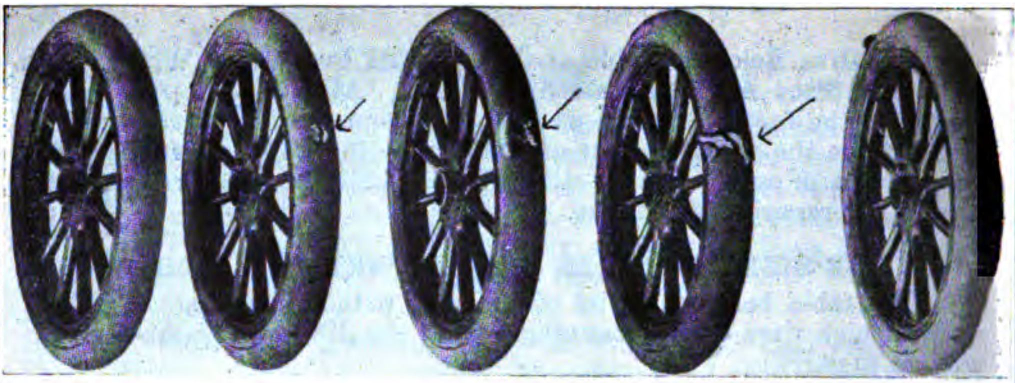
Don't Start Your Machine with a jump.

If One of Your Tires Sustains a Cut to the extent of exposing the fabric, an emergency band or patch should be applied at once.

We Would Recommend keeping an odometer of the mileage of each tire. You will find that you are getting better mileage than you would otherwise imagine.

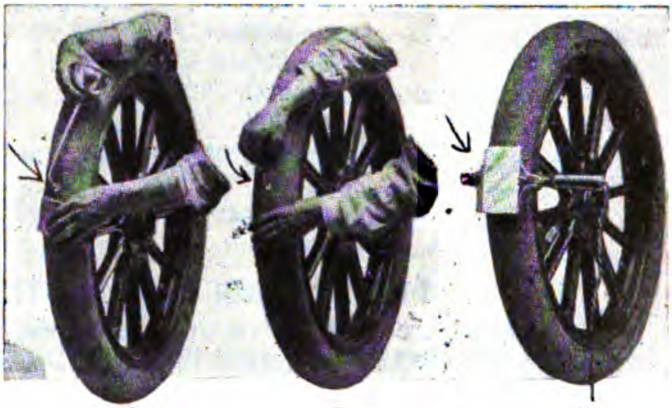
The Rims, if rusted, should be thoroughly cleaned and sandpapered, then painted with liquid graphite (common stove polish will answer).

Unless Some Pressure Is Retained the tube will have a tendency to fold and is liable to crack when again inflated.



A
Portable Vulcanizer for Home Use.

A Permanent Repair of any kind from patching a nail hole in an Outer Case to mending a Slit two feet or more in length can be made to an Inner Tube with an electric vulcanizer.



REPAIRING AN OUTER CASE.

A Set of Tires Should Be Gone Over at Least Once Every Two Weeks and the cuts in the treads of the casings sealed up by vulcanizing them. In this way deterioration of the fabric is prevented and the tires will give a mileage three times as great as that usually given by a set of tires.

Figure 1, on the accompanying chart shows a new tire.

Figure 2, shows the tire after it has been run 800 miles. Note the gash in the tread, caused presumably by sharp stones or a piece of glass.

Figure 3 is the same tire after 1,200 miles. A sand pocket has developed by the side of the gash.

Figure 4 shows the result of the neglected gash. Sand, dirt and water have been forced into it and have rotted the fabric until it has become so weakened that the inner tube has blown out through it and ruined the casing.

The Set of Figures 6-7-8-9 show how the loss of this tire could have been prevented by vulcanization.

Figure 6 shows another tire after it has run 400 miles. The gash which has occurred is being cleaned with gasoline and sand paper.

A Coating of Vulcanizing Cement is then applied and allowed to dry.

In Figure 7 the gash is being filled with new, live Para rubber.

Figure 8 shows the portable vulcanizer in place on the tire. Note that it has not been necessary to remove the tire from the rim. The vulcanizer is left on the tire, in the position shown, for thirty minutes.

Figure 9 shows the tire after the application of the vulcanizer. The gash is completely sealed up. No sand or dirt can get in to rot the fabric. The tire is now in good condition.

REPAIRING AN INNER TUBE.

The Preparation of an Inner Tube for Vulcanization is about the same as the preparation of the casing, that is, the cut in the tube is cleaned, cemented. The hole or slit is then filled with the crude rubber and a piece of the same rubber put over the hole.

After Being Prepared in This Way the Tube Is Laid Across a Shelf, usually furnished with the vulcanizer, and the flat face of the vulcanizer is clamped on the tube

It Takes About Fifteen Minutes to vulcanize a tube.

The Vulcanizer Pictured in Above Chart is an Electric Vulcanizer. The heat is supplied by electricity. The plug is screwed into an ordinary electric lamp socket. The consumption of current is about the same as one electric lamp.

Repairing an Outer Case with Electric Vulcanizer. (Shaler.) This Vulcanizer is an Ideal Vulcanizer for Home Use and Also for Small Repair Shops

CHART No. 144

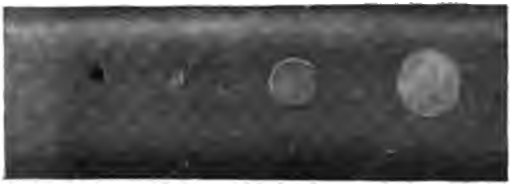


Fig. 1—Repairing Tube Puncture

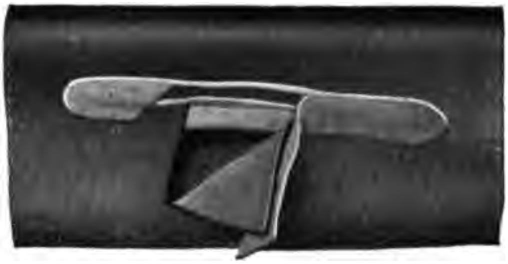


Fig 2—Repairing Slit in Tube

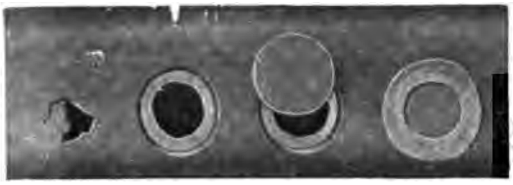


Fig. 3—Repairing Tube Blow-Out

Fig. 4—Splicing an Inner Tube

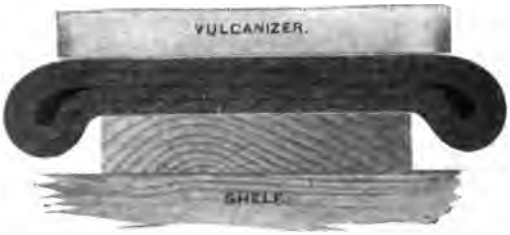


Fig. 5—Cross Secton of Vulcanizer, Splicing a Tube

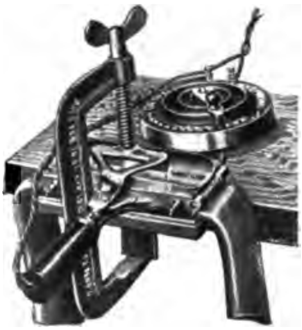


Fig. 7—The Electric Vulcanizer

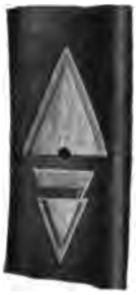


Fig. 6—Valve Stem Seat Repairs

INNER TUBE PUNCTURES.

Clean the tube thoroughly with gasoline and coarse sand-paper. Cement the edges of the hole and apply a thin layer of cement. Let the cement dry.

If a small hole, fill even with the surface of the tube with layers of Para Rubber cut the size of the hole. Cut a patch of Para one-eighth inch larger than the hole or puncture and apply over same. Then cut another patch one-half inch larger than the hole and apply over the first. Cover with waxed paper and apply vulcanizer.

Repairs of this sort are to be vulcanized for fifteen or twenty minutes at 265 degrees.

INNER TUBE CUTS AND TEARS.

Clean as directed, both inside and outside of tube; coat edges of cut and inside and outside of tube with cement and let dry.

Cut a strip of Para Rubber as wide as tube is thick, and stick on edge of cut; cut a strip one-half inch wide, place inside of tube under tear, bring edges of tear together and stick them down to this strip. (The use of semi-cured stock for the inside patch is preferable, as it obviates the use of paper inside the tube.) Apply another strip of Para Rubber one-half inch wide on the outside of the tear. Vulcanize for twenty-five minutes. Cover the repair with waxed paper before vulcanizing.

BLOW-OUTS IN TUBES.

When mending large, irregular bursts or blow-outs in which a piece of rubber has been blown out of the tube, the best method is to trim down to a clean, solid surface, making the hole somewhat regular in shape. The hole may be filled with layers of Para Rubber cut to fit.

INNER TUBE SPLICES.

It often happens that, when a tube is badly torn, it is easier to cut out a section and replace it with a new piece of tube. In making repairs of this kind be very careful not to alter the original length of the tube.

Clean the outside of one end of the tube for about four inches. Fold back the other end, turning the tube inside out, and clean for the same distance. Apply at least three coats of cement to each end. A repair of this sort requires a considerable amount of cement if no Para Rubber is used because the adhesiveness of the joint depends upon the cement alone. A narrow strip of Para between the two tubes will add to the strength of the joint. Butt the open end against the folded end and telescope the latter over it. Vulcanize in three operations, the first of twenty minutes duration; the last two fifteen minutes each. A block should be used as shown in cut to prevent pinching the edges of the tube.

VALVE STEM SEAT.

Select a good place on the tube, clean a space about four by two and one-half inches and cut a hole about one-fourth inch in diameter. Remove the nut from the valve stem and stretch hole in tube over the base of valve stem. Push the stem clear through into the tube. It is to be kept inside and away from the repair until after vulcanization. Cement entire clean surface around the hole in the usual manner, cut an oval or diamond shaped piece of Para about two by three inches, having hole in center to correspond with the hole in the tube. Roll it down on tube so that both holes register. Cover with a layer of blow-out canvas of same size and shape. Cover all with another layer of Para Rubber one-quarter inch larger all around than the first. Vulcanize forty minutes. Shake valve stem on inside of tube to the vicinity of the hole and force it through the opening until the base rests against the inside of the tube. Screw down nut on the outside and you have a repair that will never give out.

Repairing an Inner Tube with the Shaler Electric Vulcanizer

CHART No. 145

INSTRUCTION No. 33

VULCANIZING:—Steam Vulcanizer for Small Repair Shops. Prices Usually Charged for Tire Repair Work. Electric Vulcanizer for Home Work and Small Repair Shops.

The Vulcanizng of rubber is very simple. There is no "curing" needed preparatory to vulcanization. The two words are used interchangeably.

The Tire Is Made Up Into Its Desired Form and either placed in a mold or wrapped with strips of cloth so as to hold it in shape.

If in a Mold, this is placed between the plates of a steam-heated press and the contact of the press transfers the heat of the press to the mold and to the tire.

The Rubber Compound contains a certain amount of sulphur, and when heated this combines with the rubber in some way to make it take permanent shape and return to that shape when stretched or distorted.

A Very Small Percentage of Sulphur suffices to properly cure the rubber; possibly so little as three or four per cent.

The Heat Should Be Around 300 Degrees Fahr., and continued for six or eight hours.

This Long Time insures that all the sulphur combines with the rubber and that no combination takes place on every hot day during the life of the article being made. like a horizontal boiler, and the door closed tightly, after which steam under 40 pounds pressure is let in and its heat (about 300 degrees for 45 minutes) does the vulcanizing somewhat more rapidly than by the use of the mold, because of the more direct contact.

If the Tire Is of the Wrapped "open cure" kind, it is placed in a big cylindrical tank much

If the Article Is Not Wrapped or held in a mold it would quite likely be ill-shaped.

THE PROPER HEAT TO USE.

Vulcanizing Is Accomplished by transmitting heat (at a certain temperature) to iron moulds, which in turn transmit the heat to the rubber cure.

Having Decided Just What Line of Work Is Open to the Average Man, the next question is—how shall he do it? Shall the curing be done by a gas flame, electricity, or steam?

Now There Is No Special Virtue Attached to the Use of Any Particular One of these three heat sources. At the same given temperature there is no preference.

Vulcanizing Must Be Done at a Temperature That Does Not Vary More Than 5 Degrees, and steam is the cheapest medium for large repair shop vulcanizing plants for transmitting heat that will not vary more than this set amount.

At Vulcanizing Temperature, Which Is 275 Degrees Fahrenheit, a variation of steam pressure of 1 pound means but a variation of about 1¼ degrees of heat.

Steam Can Easily Be Kept Within a Variation of 5 Pounds, such a variation will do no damage.

Unless Heat Is Kept at an Even Temperature the result will be a burned and ruined job.

For Small Vulcanizers electricity is the best medium to transmit heat because it is easier to handle.

STEAM VULCANIZING PLANT FOR THE AVERAGE REPAIR SHOP.

The Right Plant Must Be Portable, Compact, Low in Cost, and of such capacity that it will be a profit maker, and so simple in operation that an old casing, an old tube, a book of instructions and an hour's experimenting furnish sufficient experience and knowledge to enable the operator to go ahead with his repairs.

A steam vulcanizing plant suitable for the average work around a garage is shown in Fig. 1, Chart 146.

VULCANIZING PLANT SUITABLE FOR A LARGE TIRE REPAIR SHOP.

Extensive Tire Repairing requires the expertness of a factory repair man, and it takes his entire attention at that.

I Mean by This, the Kind of Tire Work that deals with jobs cut down upon the external surface, and requiring pounds of raw rubber to replace that removed to make the repair.

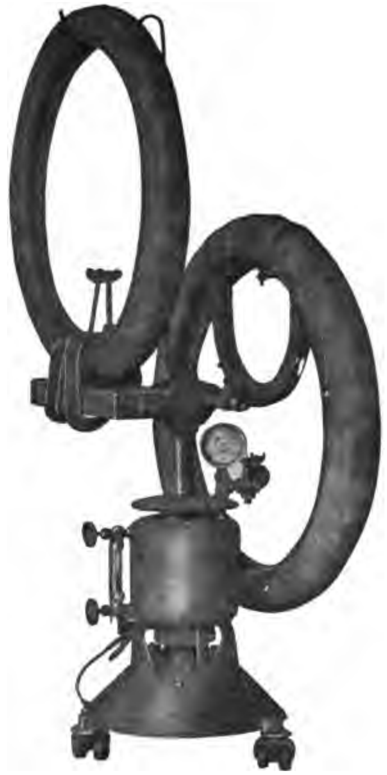


Fig. 1 — **The M.A.C. Steam Vulcanizing Plant**, which will repair outer cases and inner tubes and suitable for the average work around a garage.

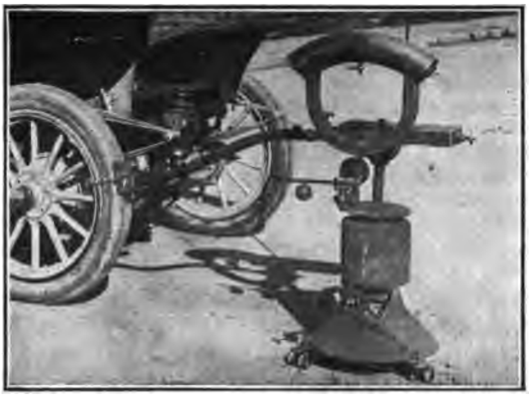


Fig. 2—Illustration Showing this M.A.C. Vulcanizing Plant Repairing a Tire on a Wheel
The Vulcanizing Plant is Portable

A PLANT OF THIS KIND WILL DO THE FOLLOWING WORK:

Repair inner tubes from punctures to long cuts and replacements of sections in tubes, and inner casing work. It takes care of the curing of sand cuts, gashes, loose spots in the tread as well as completely relining tires, and doing much sectional casing work of the class which can be re-enforced and built up on the inside of the tire, and does not call for the removing of large quantities of rubber and friction fabric.

EXPLANATION OF CONSTRUCTION AND OPERATION OF THE M. A. C. STEAM PLANT.

The vulcanizing plant above consists of a substantial flaring base, set upon heavy castors to facilitate moving the plant from one portion of the shop floor to another, and directly on this base is set a cast-iron steam boiler, fitted with two flues and a heat deflecting plate at the top, and this boiler is heated by a very efficient double gasoline burner.

The boiler is equipped with safety devices, such as water gauge, steam gauge and safety valve.

The steam rises from the little generator, enters a steam dome and is distributed from this to the tube arm, the relining mould and the extension steam arm. This consists of the tube arm 15 inches by 5 inches. A relining mould which will take in tires of every size from 3 inches to 4½ inches, and the extension steam arm which can be clamped to any tire of any size and cured, and cures sand holes, cuts, etc., without removing the tire from the rim.

This extension steam arm can be operated at all times with the rest of the plant, or can be cut off by means of a valve.

TO OPERATE THE PLANT.

The boiler receives water until it stands at ¾ gauge in the water glass. One-half gallon gasoline is put into the cast-iron gasoline tank elevated above the plant. A very light air pressure is put on the gasoline by means of the bicycle pump.

The burner is generated in the same manner as in any gasoline stove burner, and in 15 minutes after the gasoline is ignited a steam pressure of 50 lbs., or more, will show in the steam gauge. The plant is then ready for use, and the 50 lbs. steam pressure can be maintained for several hours with a very low flame, and with scarcely any loss in water.

Repair Shops in Small Towns Can Do a Thriving Business with a Vulcanizing Plant of this Kind

CHART No. 146

The Kind of Job That Extends Over the Bead and requires a whole battery of special bead moulds to complete it.

The Tire Repair Jobs That Can Be Done by Repairmen, dealers and owners are those blow-outs that result from sand holes and deep cuts, but which do not extend for any great distance along the tire. Sand blisters and minor cuts not puncturing the carcass, and the tube work of every description is the range of action open to all who do not claim to be expert in tire repair work.

Unless a Person Has Had Especial Training in the tire repair business, I would not advise him to attempt the more difficult jobs, but send them to the factory tire repair plant.

This will be profitable as a discount is always allowed a dealer who is in the business.

THE STANDARD PRICE CHARGED FOR TIRE REPAIR WORK IS AS FOLLOWS:

INNER TUBE REPAIRS.

Inner tubes repaired—1st vulcanize 75c; 2nd vulcanize 50c; 3 or more 35c.
Putting new valve in inner tube, 75c.

TIRE CASE REPAIRS.

6-inch section in 4-inch case	$4.00
6-inch section in 3½-inch case	3.50
6-inch section in 3-inch case	3.00

50c added per inch up to 10 inch, then 25c. If rubber is cut and fabric not injured, the cost will be 75c.

INSTRUCTION No. 34

A GARAGE:—Building a Home Garage. Garage for Business. Tools and Equipment.

The Practical Motorist takes a pleasure in the execution of minor repairs and adjustments to his car and caring for same.

With a Great Majority of Motor Car Owners, both present and prospective, the garage problem is one of much importance.

To House a Car in a Public Garage Involves a Very Considerable Monthly Expense; the care taken of the machine is not always satisfactory; and unless the garage is close at hand this arrangement usually presents some little inconvenience, and especially to those owners who operate their machines themselves.

Moreover There Are Large and Increasing Numbers of Autoists to Whom the Upkeep of Their Cars is a Pleasant Diversion, which together with the economies resulting from caring for their machines themselves, are denied when the machines are housed in the ordinary public garage.

On the Other Hand, to Expend Several Hundred Dollars in Erecting a Private Garage Even on One's Own property is frequently objectionable and the average man hesitates still longer to make such an investment on rented ground which he may not desire to occupy permanently.

To Meet This Situation and Provide an Inexpensive Private Garage which can be moved readily if desired and which will be fireproof so as to meet even the most rigid building and insurance regulations, recourse may be had to corrugated iron or sheet iron in other forms, with results which will be entirely satisfactory.

CONSTRUCTING AN INEXPENSIVE HOME GARAGE—FOR A SINGLE CAR.

Under a Proper Design, using standard stock materials, a substantial and attractive building sufficiently large to house one car and leave ample shop and work room, and which will accommodate a visiting car on occasions, can be secured for as little as $50, excluding labor, and if the owner does not care to himself do the work of erection, which is very simple, the whole finished garage, including labor, need not involve an investment of more than $75 or less.

THE FLOOR PLAN.

The Space Usually Occupied by a Touring Car of Average Length and the remaining shop and work room space is shown in Fig. 1, Chart 147. The size of same being 12x16 as outlined in the frame work, Fig. 2.

THE SIDES AND ROOF OF THIS GARAGE.

In This Particular Garage, sheet iron, formed to represent rock-faced stone, was used for the sides, with regular corrugated iron for the roof.

PAINTING.

With Drab Paint on the sides and red paint on the roof it was difficult at short distance to distinguish this building from one built of stone, with a red tile roof, and the whole appearance is very pleasing.

ROOF.

The Roof is of the common V-roof frame covered.

DOORS.

The Right Door is hung one foot from the corner, while two feet are left on the opposite side, where space is provided for the work bench.

The 9 Feet of Doorway provide ample clearance for the entrance of the machine, which is substantially 6 feet wide over the running boards.

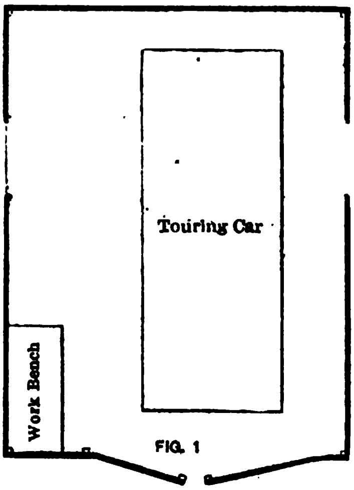


FIG. 1

Fig. 1—Plan of the little garage showing the space utilized for the touring car and the working space around it.

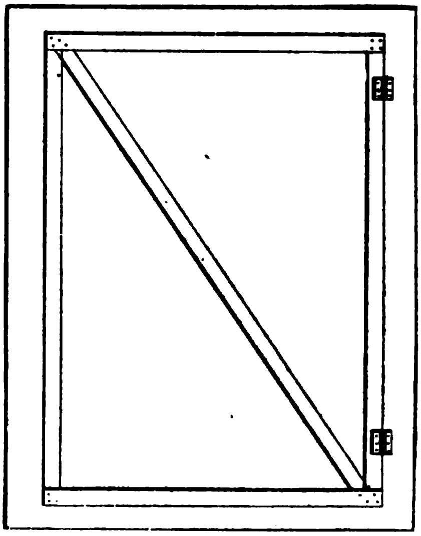


Fig. 3—Big door of the little garage, presenting the plan of the framing, showing the diagonal bracing to prevent the door from sagging.

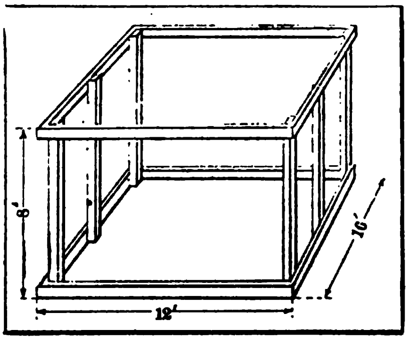


Fig. 2—A skeleton of the building, showing how the framing is joined.

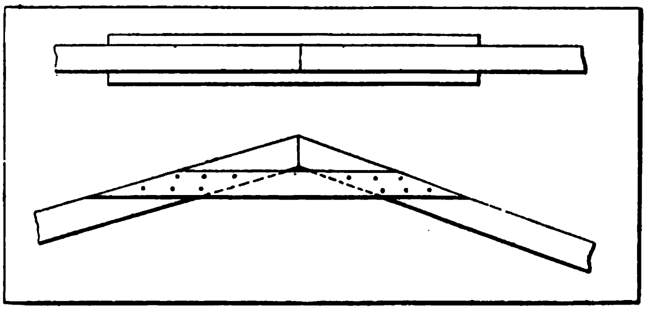


Fig. 4—Roof framing; a simple plan; as strong as it is easy to make.

Plan of a Fire-Proof, Inexpensive, One Car Home Garage, Based Upon Actual Experience in an Effort to Solve the Problem of Storing the Car

CHART No. 147

WINDOWS.

One Window on Either Side, located about two-thirds back, furnishes ample light and ventilation. The doors should each be 4 ft. 6 in. x 8 ft. high.

The Size of the Windows should be made to suit the size of material used for the sides of the building.

MATERIAL FOR THE FRAME.

The Framing of the Structure, which is made entirely of 2x4s in standard lengths, will be the same, irrespective of the material selected for the sides and roof.

The Following Pieces of 2x4s Will Be Required for the Frame: For the uprights eight pieces 8 ft. long; for the horizontal members, four pieces 16 ft. long, and four pieces 12 ft. long; for the roof, four pieces 12 ft. long.

There Will Also Be Required for the Stiffening of the Roof Frame. Eight pieces of 1x3 inch material, 8 ft. long.

For the Doors, 1x3 material will be required as follows: Four pieces 8 ft. long; four pieces 4 ft. x 6 in. long; two pieces 12 ft. long.

To Erect the Frame of the Building, form a 12x16 ft. rectangle on the ground with two pieces 2x4s, 16 ft. long and two pieces 12 ft. long. Nail the corners securely with wire nails about 5 inches long, placing the four sills on edge.

Then Nail 8 Ft. Uprights Inside Each Corner and nail to their tops a rectangle of two 16 ft. long and two 12 ft. long pieces similar to that formed by the sills.

Two Additional Uprights Are Then to Be Placed on the Sides, midway from the front to the rear, all as shown in Fig 2.

Two Additional Uprights are to be used for the hanging of the doors as shown in light lines.

THE SIDING.

The Simplest Siding Is Made of Standard Corrugated Iron, in 8-ft lengths, with two 2½-inch corrugations.

If This Material in 24-gauge Galvanized costing about $4.40 per square (100 square feet) is used two pieces of 1x3-inch boards 16 ft. long and two pieces 12 ft. long will be required in the framing of the sides.

These Pieces Are to Be Nailed to the Sides of the 2x4 Frame half way up or 4 feet from the ground.

The Total Cost of the Corrugated Iron for the Sides will be about $20.00.

ROCK-FACED STONE SHEETING.

For About 10 Per Cent. More Sheet Iron, Stamped to represent rock-faced stone, can be secured.

The Strips of the Latter Run Horizontally, however, instead of vertically, and with them three nailing strips 1x3 in. will be required on each side, calling for six pieces 16 ft. long and six pieces 12 ft. long.

With Either Character of Siding the doors can be framed and covered conveniently, but with the rock-faced stone sheeting, which comes in lengths of 5 feet, it is simpler to make each door an even 5 ft. wide, instead of 4 ft. 6 in., and this extra width of the doors will be found to be an advantage rather than a disadvantage in the use of the garage.

Both Kinds of Siding Are Fastened to the Frame With Special Wire Nails and washers which are procurable with the sheet metal at a few cents a pound.

About One Pound of Nails Will Be Required for each 200 square feet of siding.

The Roof Is a Simple V Roof, for the framing of which six pieces of 2x4, 8 ft. long and one piece 18 ft. long will be required, together with two pieces of 1x3-in. material, 18 ft. long.

The Six Pieces 8 ft. long run from the peak, which should be elevated 3 feet to give good drainage to the eaves and provide for an overhang of the roof of about 8 inches, after the fitting at the peak is done.

The 16-Ft. 2x4 Is the Ridge or Peak Member and the 1x3 are nailing strips to be placed midway between the eaves and ridge.

GALVANIZED IRON ROOF BEST.

Galvanized Corrugated Iron Is the Best Material for the Roof, no matter what siding material is selected.

It Is to Be Bought in 8-Ft. Lengths also and nailed on directly to the roof frame.

To Make the Ridge Water-tight, a piece of ridge cap 18 feet long will be required. This is standard material which can be secured with the other iron.

WINDOWS.

In Providing Windows, glazed sash about 24x30, as may best suit the width of the siding used, may be found in most lumber yards at from 50 to 75 cents each and may be easily arranged to run in simple slots nailed to the strips.

FLOORS—CONCRETE, CINDER OR BOARD.

To Provide a Smooth and Satisfactory Floor a cheap concrete made of one part cement, four parts sand and six parts graven or crushed rock or even cinders, may be employed, this floor costing about five cents per square foot; or a light board floor can be laid for a total cost of about $10.

For Anything, Except Indefinite, Permanent Use, a Couple of Loads of Cinders costing about $1.00, delivered, answer all requirements, providing the cinders are tamped firmly into the ground. This latter character of floor will be reasonably smooth and will absorb oil, water and other moisture without disturbing the smoothness and without making any mud.

DOORS.

The Doors Are to Be Framed to the Width Selected, About as Shown in Fig. 31, which provides ample braces to keep the doors from sagging or getting out of shape.

With Either Construction of the Sides or Roof mentioned, the work will be found to be simple and the result satisfactory.

The Problem of Construction Is Well Within the Mechanical Scope of Any Person having the slightest aptitude of mechanical plans, and work, and the finished appearance, in any case, will be pleasing, especially if the building is painted after completion as suggested.

If Portability Is Desired, it will be found entirely possible to dismantle the building at a future date and re-assemble it in another location, without any difficulty and without any loss of material except possibly a few nails, representing an outlay of a few cents.

In Putting Up a Building of This Character it is well to remember that there are ordinances and insurance regulations that will have to be complied with. In some localities it is necessary to allow a certain distance between the residence and the garage.

SPECIFICATIONS FOR A TWO-CAR HOME GARAGE WITH CONCRETE FLOOR AND OF FINER CONSTRUCTION.

The Dimensions of This Garage are 16x30 feet inside, 8 feet high to eaves, 3 feet to be of concrete wall 8 inches thick with 5 feet of 2x3 studding on top of wall and wood finish above. (See Chart 148.)

The Inside Contains, main room for auto 16x17 feet, cement floor, with two inch slope to the center for drainage, which may be connected with the sewer or catch basin dug outside the building and piped under ground.

Two Rooms, Each 8x13 Feet, are partitioned off in the rear, one for a shop and the other for chauffeur; a lean-to is built 6x14 feet for heater, toilet and coal, thus removing as far as possible any liability to explosion, by having two doors.

Bench, With Vise, Oil Shelves and Closets are to be placed at the discretion of owner.

Roof of Lean-To may be a continuation of the main building roof.

This Addition is to have a door with glass panel, and slide for coal, if wanted.

Outside Finish Is Siding nailed to 2x3 studding, bedded into top of concrete wall 2x4, by placing spikes on two sides, driving them halfway in.

Let the Top Come Flush With the Inside and top of the inner form; outside form to be one inch lower and concrete neatly troweled to a level for water table.

Inside Finish to be galvanized iron, painted or plaster board.

Entrance Doors, having glass panels, are hung on easy running inside tracks.

The 2x4 Around the Building on Top of Concrete Wall is to nail studding to.

The Gasoline Tank is to be buried outside and piped under the wall to a pump in the large room.

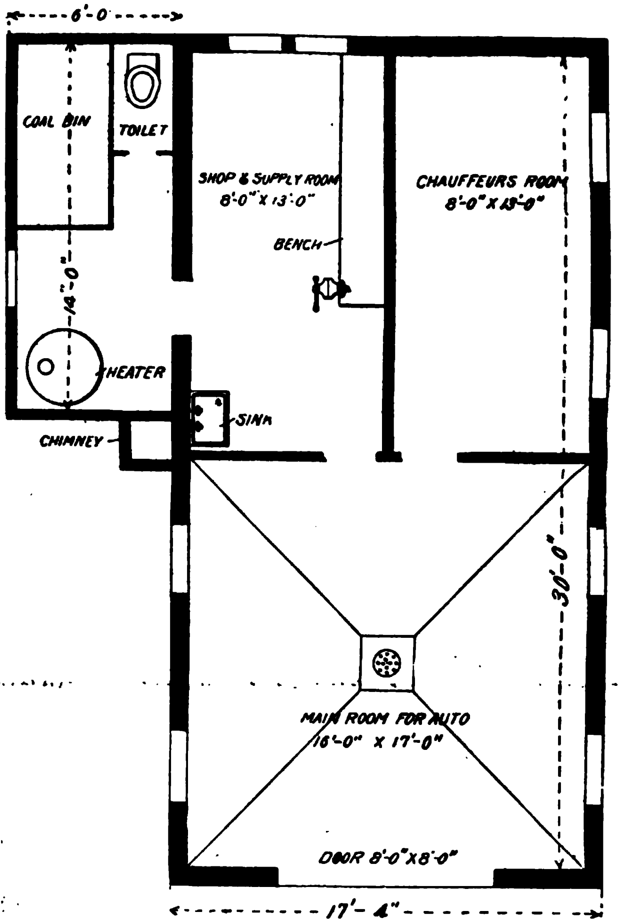


Fig. 1—Floor Plan for a Two Car and Shop Garage

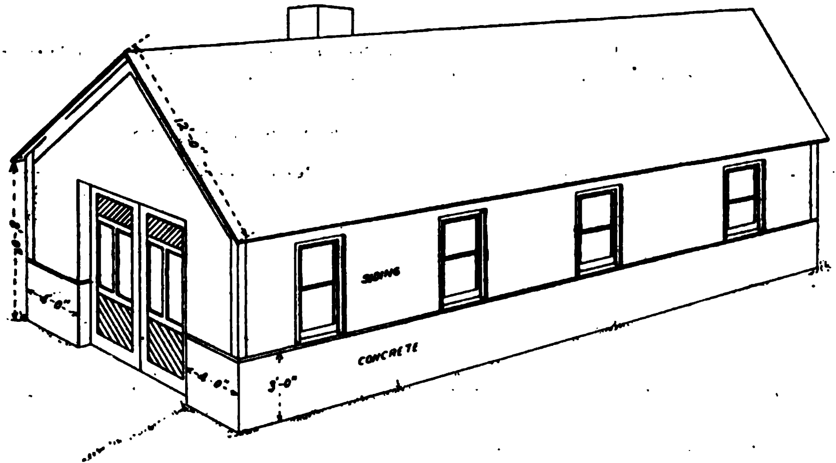


Fig. 2—General Outside Appearance
Perspective View

Plan of a Two Car Garage with Concrete Floor

CHART No. 148

When Desired a Basement Under the two small rooms with heater there might be safer.

This Building, two feet longer, with doors on the side of double construction, will accommodate two cars.

ESTIMATE OF COST.

Foundation and three feet of concrete wall	$ 85.00
Concrete floor	35.00
Drainage	25.00
Water	20.00
Chimney	25.00
Heater	75.00
40 pieces 2x3 in. x 16 ft	9.10
50 pieces 2x4x12 feet	11.20
6 pieces 2x4x16 ft	.90
550 feet of siding, at 40c	22.00
750 feet of roof boards, at 28c	11.00
250 feet of corner and finish boards	8.50
7 sash and frames, weights and cord	16.00
3 inside doors and hardware	5.00
2 entrance doors	20.00
1 outside with glass door	3.00
Roof Covering	65.00
Inside Finish	50.00
3 pieces 2x6x16 for tank and benches	1.40
Labor	112.00
	$600.60

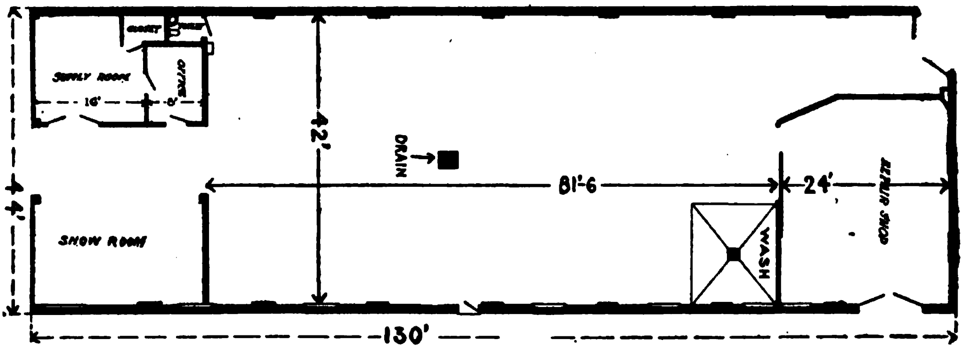


Fig. 1—Floor Plan of Garage Suitable for a Small City. The Salesroom, Supply Room, Office, Repair Shop, Garage, Etc.. on One Floor.

A REPAIR SHOP AND GARAGE FOR BUSINESS.

If the Reader Contemplates Entering the Auto Repair and Garage Business, there are many different ways to build a garage.

The Illustration in Fig. 1 above shows a plan for a one-story garage.

The Floor is made of cement or concrete with a wash in the rear near the shop.

The Shop must be partitioned off (insurance says with a brick wall) see plan for measurement.

The Walls and Front are quite often made of concrete blocks or of brick or even metal.

A Sky Light ought to be provided unless there are plenty of windows on the side.

There Must Not Be Any Posts in the center, beams must be used to span the 42 feet.

The Wash, 12x18 feet is in the rear near the repair shop.

By Referring to Illustration above, an outline of plan of this garage will be shown.

While One-Story Garages Are Most Common, still there are many who favor a two-story building so that the second floor can be used for the repair shop.

In Case of a Two-Story Building, the stairway will have to be added.

The Width of This Building is 44 feet outside and 42 feet inside; this will permit cars to be stored on both sides of the building with passageway between. A 50 foot width would be better.

A Nine or Ten Foot Entrance is desirable.

Drains are arranged as shown.

A Heating Plant, by hot water or steam with coil pipes for radiators must be provided. This plant should be in a cellar or on the outside of the building in a small brick enclosure.

A Turntable is very handy for garages and should be placed in the center of the garage.

A Stock Room must be provided.

The Gasoline Supply should be stored in an underground tank, placed some distance from the building, from which it is piped to a pump located inside of the building near the wash.

The Gasoline Tank should have from 150 to 560 gallon capacity.

Lubricating Oils should be carried in about three grades: light, medium and heavy gas engine cylinder oil, also gear case oil and greases.

Sixty Gallon Tanks are usually provided for lubricating oils and all are placed near the gasoline pump.

A Forge is indispensible; if it burns coal, should be under a separate roof. Gas is used quite extensively, however, for this purpose and may be placed in the shop.

An Inspection Pit is useful, placed at any convenient place where the auto can be run over it. The pit permits the repairman to get under the car and work and should be in the shop.

The Writer's Pit is 6 feet long, 2 feet 9 inches wide and 2 feet 9 inches deep.

A Mirror is very handy for throwing the light in dark corners when at work in the pit under the car.

A Chain Hoist, for lifting the engine and other heavy parts, will pay for itself many times over in time and labor.

Fire Extinguishers must be kept handy. The only part of the building, if made of concrete or brick, that is liable to fire is the roof.

In Case of Fire—keep two or three buckets of sand handy to put out a gasoline fire as water is useless.

A Water Connection in the motor shop will be handy and should be installed.

WORK BENCH FOR THE REPAIR SHOP.

In Deciding Upon a Suitable Position for the Working Bench, if it is possible to fix it where there is plenty of light, say, alongside a window, this should be chosen in preference to elsewhere.

The Workbench should measure 8 or 10 feet long, 2-inch thickness of well seasoned pine, or better, birch. The harder the wood the better. The height should be about three feet. The width about 2 feet to 2 feet 6 inches.

Th Vise Should Be as Close to the Door as possible. As most work is done in the vise, there is less loss of time in moving backward and forwards from the motor car to the vise.

Shelves and Racks for tools, such as stocks, hack saws, etc., should be on the walls at the back of the vise.

A Set of Stout Drawers for keeping bolts and screws and brass rods should be provided. Some of these drawers should be fitted with locks and keys, for sometimes tools will disappear. Several shelves should be put up for storing various spare parts, mandrils, etc., but it must be remembered that the shelves when full may have to carry a very considerable weight; they should be stout and well secured.

LIST OF TOOLS FOR FITTING UP THE REPAIR SHOP.

Vice: 3 to 6 inch vise.

A Pair of Copper Clamps—2 pieces of sheet copper ⅛ inch thick and 3 inches square, placed half their length in the jaws and then bent over to rest on top of the vise. Copper is soft and will not hurt work placed in the vise.

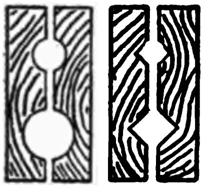


Fig. 1—Vise Clamps

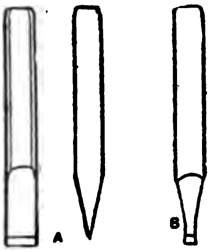


Fig. 2—Chisels

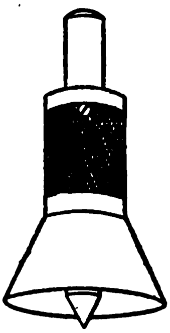


Fig. 3—Bell Punch

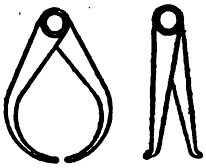


Fig. 4—Calipers

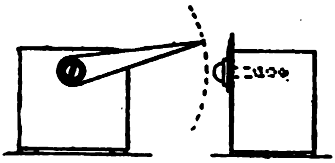


Fig. 6—Scribing Block

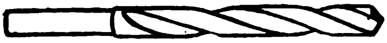


Fig. 9—Twist Drill

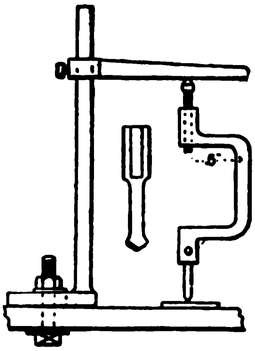


Fig. 7.

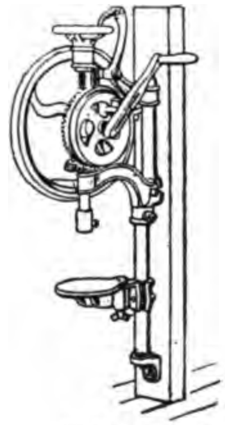


Fig. 8—Hand Drilling Machine

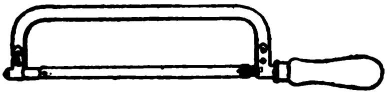


Fig. 12—Hack Saw

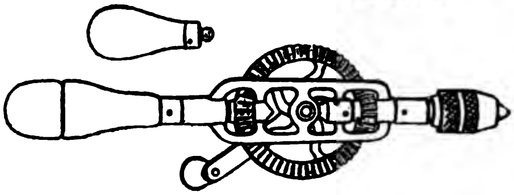


Fig. 10

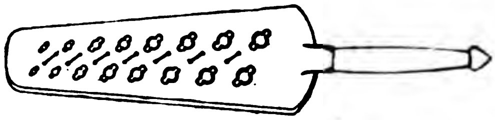


Fig. 11—Screw Plate

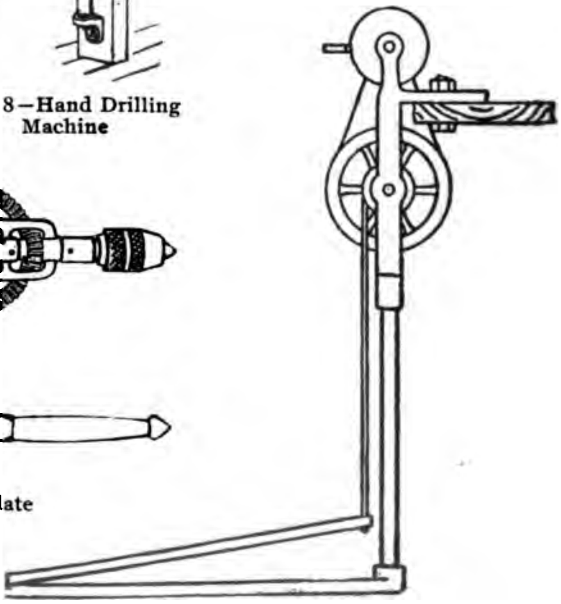


Fig. 14—Emery Wheel

Useful Tools for a Home Garage

CHART No. 150

A Pair of Wooden Clamps made of hard wood with holes bored through and then sawn across, about ¼ inch or more being cut away; or they can be cut to a V. These later will take pipes of various sizes without injury. (See Fig. 2.)

Steel Bars: Few feet of ¼ inch, ⅜ inch, ½ inch, ⅝ inch, ¾ inch, ⅞ inch and 1 inch iron bars, also some of steel for bolts (round bars are termed rods, square or rectilinier are known as bars), also a few feet of ¼x¼ or 1¼x⅜ to make plates for holding work in a lathe.

Files: 1—12-inch flat file, 1—8-inch half-round, 1—7-inch flat, 3—round files—½-inch, ⅜-inch and ¼-inch, 1—rat-tail file (this is a small round file a little over ⅛ inch diameter), 2 square files—⅜-inch and ¼-inch, 3 triangular files, usually called saw files.

Chisels: About 6 chisels will be wanted; 2 flat and 4 narrow or cross cut See Ill. Fig. 3. Two of these would be under ¼ inch wide for cutting keyways. A diamond pointed chisel is useful.

Miscellaneous. File cleaner, steel straight-edge, 3 inch square, pair compasses, center punch, a bell punch, see Fig. 4, useful for centering rods for the lathe, inside and outside callipers Fig. 5, hack saw, oil can, spanner wrench.

Hammer: 1 engineer's hammer with flat and rounded face, the head should weigh about 2 pounds. 1 riveting hammer.

Scribing Block: See Fig. 6—made from a block of hard wood with three drawing pins for feet and a movable steel scriber screwed on.

A Swing Brace or Drilling Machine: A substitute for a drilling machine is illustrated in Fig. 7, which shows a swing brace. The post is 1¼ inch iron and 2 feet long. The foot has a slot to take a ⅜ inch bolt. It is bolted to the bench. There are many drilling machines on the market ranging from $5.00 upwards.

Twist Drills: A set from ⅛ to ½ inch advancing 1-32 inch., 1 9-16 inch drill. Purchase drills to fit your socket of drill press.

Hand Drill: This type of drill usually contains drills suitable for its use in the head of the handle. Hand drills cost from $2.50 to $5.00.

Taps and Dies—A set of Whitworth or similar taps and dies should be bought to cut from ¼, 5-16, ⅜, 7-16 and ½ inch. A set usually costs from $8.00 to $15.00.

There are Two Sorts of Taps, the taper and plug. The taper has the threads at the point cut away; it is in fact a cone.

The Plug Tap has the threads full size nearly to its end. In tapping, it is needless to say that a hole must be drilled first. This must be smaller than the size of the screw required; for a ¼ inch nut the hole should be 7-32 inch, or 1-32 inch less than the ¼ inch, for a 5-16 inch to ½ inch hole the drill may be 1-16 inch less.

Fig. 11 Illustrates a Screw Plate of old style, but handy for cutting small threads.

Emery Wheel.—A very useful tool is an emery grinder. The writer prefers these worked by a treadle, as the hands are free to hold anything to be ground. It screws on to the bench. For grinding anything a file will not touch it is invaluable. It is a bad plan to use an emery wheel in a lathe—the lathe does not run fast enough, and the dust from the wheel must be injurious to the surfaces of the lathe. If shop is equipped with power then get a power emery grinder.

A Lathe, Power Drill, press and power emery wheel are all desirable.

A Lathe for Ordinary Work would answer of the foot power type. A lathe to take a 5 inch chuck will meet all ordinary requirements.

POWER.

A Power Motor should be installed of either a gasoline motor and electric motor together with a line shaft.

LATHE AND POWER MACHINERY.

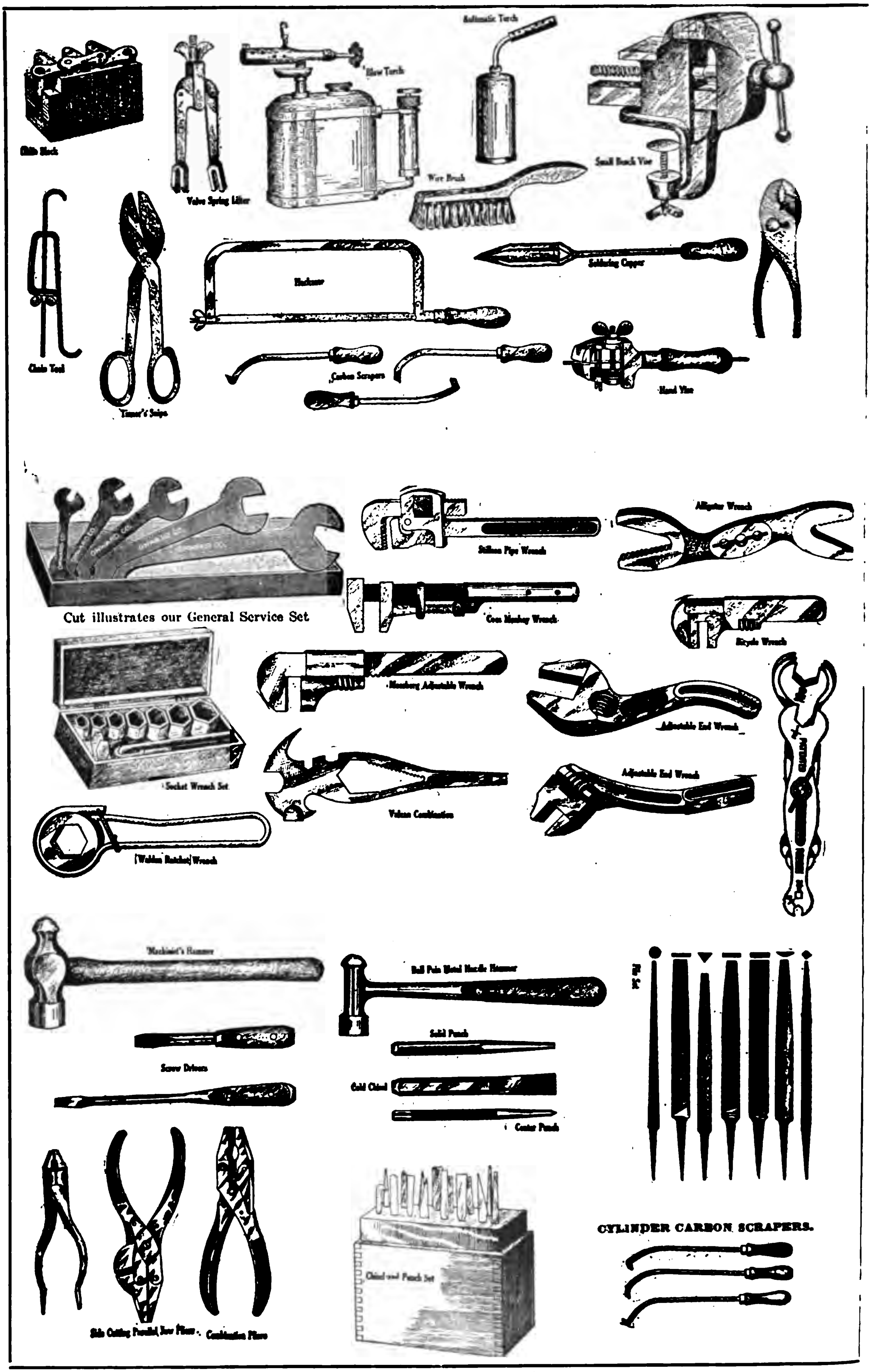
A Lathe capable of centering crank shafts, axles, or most any part of an auto, should be installed.

If One Lathe only is to be installed, I would recommend a 14 inch.

If Two Lathes are installed make the other 18 inches by 6 feet.

A power drill press with 16 inch swing table.

Drills for same, ⅛ to ½.


Cut illustrates our General Service Set

A Well Assorted Lot of Small Tools

CHART No. 151

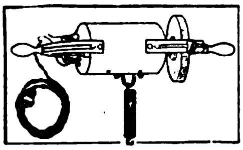


Fig. 5—Portable Electric Buffer and grinder, can also be used for polishing and various purposes.

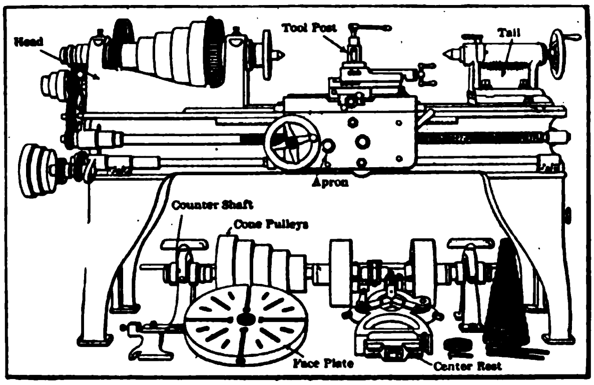


Fig. 2—Lathe, 18, 20 or 22 inch swing

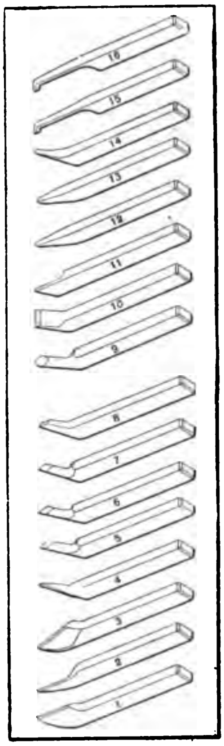


Fig. 3— Hand Forged Lathe Tools—a complete assortment.

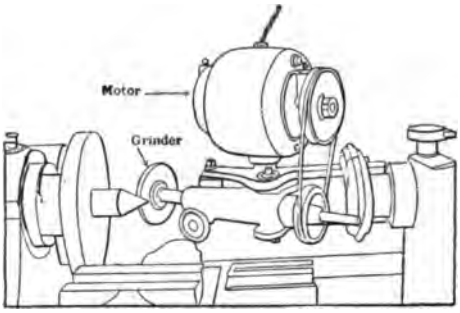


Fig. 1—Motor Driven Grinding Attachment for a Lathe, to be used for dressing tools, grinding centers and taper.

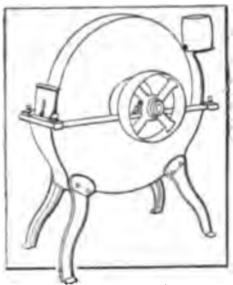


Fig. 6—A Grindstone

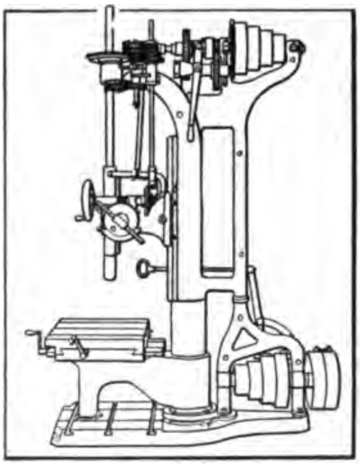


Fig. 4—A 24 Inch Drill Press fitted with a Compound Table

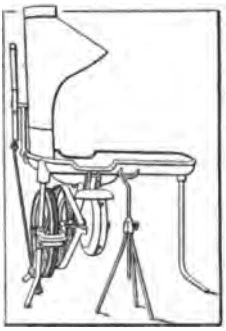


Fig. 7—A Blacksmith's Forge. There are also Gas Forges which are less trouble but more expensive to operate.

Suggestions for Equipment of Machinery for a Repair Shop

Chart No. 152

A Sensitive Drill press with drills, 1 to 60.

Power Emery grinder, 10 inch, with ¾ shaft.

For a very complete set of machinery see Chart —.

PRICES USUALLY CHARGED IN A GARAGE.

Large cars stored, washed and polished, per month	$20 to $25
Medium and small cars stored, washed and polished, per month	$15 to $25
Cars on dead storage, not used	$ 5 to $ 8

A Garage Man Does Not Insure the Cars stored with him, that being something which the owner himself must attend to.

Gasoline retails from 15c to 20c per gallon.

Washing car and polishing, $1.00.

Repairs charged from 60c to $1 per hour.

Helper's time counted half.

An Extensive Line of Repair Work can be carried on in this garage and the sale of extras and sundries will add materially to the income.

The Renting Business is something worth considering and can be added in time.

TIME TO OPEN A GARAGE.

The Best Time of the Year for Opening a Public Garage is in February. At that time owners are getting their cars out of dead storage, are buying new machines, or if they are dissatisfied with the place in which they are storing their cars, they are prepared to make a change.

It Doesn't Make Much Difference as to the Size of the City. It is estimated that a garage 100 by 125 feet and one story high, capable of accommodating forty cars, can be equipped at a cost of around $1,000, which would include wash rack, lathe, and other machinery necessary for the operation of the repair shop.

WHAT TO CHARGE ON TIRE WORK.

If a Vulcanizing Plant Is Installed for Tire Repairs, the charges average about as follows:

INNER TUBE REPAIRS.

Inner Tubes Repaired—1st vulcanize 75c.
2nd vulcanize 50c.
3 or more 35c.

Putting new valve in inner tube, 75c.

TIRE CASE REPAIRS.

6 inch section in 4 inch case	$4.00
6 inch section in 3½ inch case	$3.50
6 inch section in 3 inch case	$3.00

50c added per inch up to 10 inch, then 25c.

If rubber is cut and fabric not injured, the cost will be 75c.

INSTRUCTION No. 35

REPAIRING:—How to Use Tools. How to Make Adjustments and Repairs.

The Auto Repairman Must Know how to adjust any part of the car.

To Know How to Adjust, He Must Know the Principle of the construction of the parts as explained in previous instructions, and must know when and where to look for trouble.

About One-Half of the Work of the Automobile Repairman is for Making Adjustments and Fitting Parts; such as carburetors, horns, lamps, coils, grinding valves, fitting new piston rings, fitting bearings and numerous other little details, which does not require a machine shop, but does require a good assortment of tools, and a knowledge of the principle of the construction of a car.

A Machine Shop is Not Necessary, unless there is sufficient work to keep more than one machinist busy. A great number of small repair shops only put in just the tools needed for the average repair work, and when they have a job of machine work to do, they take it to a machine shop.

In Other Words a Machinist and an Auto Repairman are two different trades.

A Good Auto Repairman Need Not Be a Good Machinist; I mean by machinist, one who can turn all kinds of metal parts out on a lathe and do actual machine work.

Therefore We Will Explain Only the Work the Average Auto Repairman is called upon to do.

HOW TO USE TOOLS AND MAKE LIGHT REPAIRS.

The Art of Filing Flat is a very difficult one; no man can file truly flat. The reason is not very far to seek: Fig. 16 represents the position of the file at the beginning of the stroke. If the pressure of the hands be equal through the stroke, it will be greatest on the corner nearest the workman at the commencement, and on the other corner at the end of the stroke, and will tend to form a curved surface by imparting a slight rocking action to the file. Therefore, the pressure on the file must be greatest on the left hand at the beginning of the stroke, and as the file crosses the work, must be gradually diminished on the left hand and at the same time increased on the right hand. Notwithstanding this, it is impossible to file truly flat. If the work be examined with a straight-edge it will be found the higher in the middle. To reduce this high part recourse must be had to draw filing (Fig. 17), holding the file by both ends and working it backwards and forwards across the middle of the work. This will considerably reduce the high part.

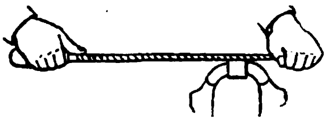


Fig. 16—Filing

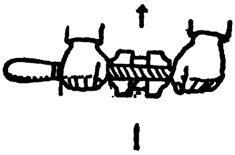


Fig. 17

Fig. 19—Flat Bottom Drill

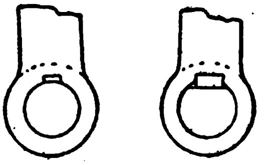


Fig. 20

A—Keyway Marked Out. B—Flat Keyway

To Cut a Rod or Bar of Iron, it should be held on an anvil by an assistant, and then nicked all round with a flat chisel and hammer, when after a time it will break off; or it may be held in a vice, the chisel just resting on the jaws of the vice, and hit with heavy blows of the hammer, the rod or bar being turned round in the vice after every three or four blows. But at the present time when hack-saws are much better than formerly, the best way is to saw it off, using oil or soap and water as a lubricant.

CUTTING KEY-WAYS.

Key-Way Cutting With a Chisel is an Art that requires considerable skill. There are many men who can cut a key-way nearly as well as it can be done by a machine, not so the amateur. The first thing to do is to mark out on the shaft the key-way required, with a line to show the center. It is best to have a few flat-bottomed drills (Fig. 19) and drill a series of holes in the shaft to the depth of the bottom of the proposed key-way. The holes should not be in actual contact, if they were so they would run into one another. Then with a narrow chisel chip away the intervening spaces and file with a small square file. As a square file is not an actual right angle at its corner, the angles of the key-way would be rounded off; therefore work these corners square with a saw file, but as a saw file is not cut (that is, has no teeth to the top), the top must be broken off to allow the saw to work up to the ends of the key-way. The key must be of steel, fitted to bend down on the bottom of the key-way and tight at the sides. Rough keys of different sizes can be bought at toolshops. It will save time in fitting if a dozen or two are procured.

To Cut the Key-Way in the Wheel or boss to fit on the shaft, the key-way must be marked out A (Fig. 20) on the boss at each side exactly opposite. This must be done carefully with the square, and lines scribed through the bore of the wheel. If, however, the key-way in the shaft is longer than the boss, the boss may be marked from the key-way. The metal must then be chipped and filed away and tested with a straight-edge. The key-way will be found to be shallowest in the middle; this high part must be worked down, using the edge of a flat file, or making the end of a square file into a scraper by grinding it on the stone at an angle of about 40 or 35 degrees. (Old files should be put aside for this use.) The flange or end of a file that goes in the handle may often be used for making keys. It must be remembered that the key and key-way must be very slightly tapered. The key must be inserted and tapped gently in and then driven out, and it will be noticed that it bears hard in one or two places. These must be filed down, preferably by draw-filing, and the key again tried. This operation must be repeated until a good fit is obtained, and the key is driven home with a heavy hammer. If the shaft projects from the boss, a drift should be used to prevent damaging the key-way by the blows of the hammer.

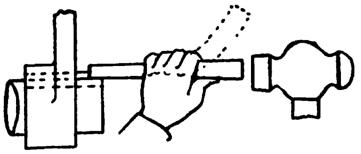


Fig. 21—Drift, Driving in Key.

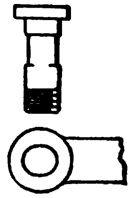


Fig. 22—Worn Steering Pin and Rod

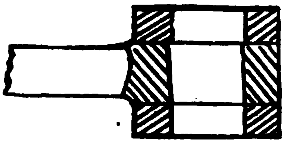


Fig. 23 Drill Gone Wrong, Showing Hole Uneven

The Drift (Fig. 21) is a Steel Tool with a hardened nose. They are sometimes curved (note the dotted lines), as in many cases it is impossible to get a straight blow at a key. Care should be taken not to burr up the end of the key. A piece of stout copper held over the end of the key by an assistant will prevent this.

Keys are Sometimes Used with a Flat Surface on the Shaft of a key-way, but this method should only be used when the strain is in one direction only, and not for severe strains (see B, Fig. 20). The key on a flat shaft is more likely to get loose than when it is placed in a sunken key-way. A flat key is usually wider than a sunken one.

When a Key-Way is Not at the End of a Shaft and the key being sunk cannot be driven in, the key is first placed in position, and the wheel or boss driven on to its right place.

A Set Screw is Sometimes Used in Place of a Key. It is not such a reliable way of securing a wheel to a shaft, but it may be used for collars, to prevent a shaft shifting sideways in its bearings. The ends of the set screws should be rounded off and pointed and case-hardened.

Drilling a Hole Through the Boss and shaft seems to be a favorite method with some makers to secure the two together. The hole is reamered out with a reamer, which is a taper steel tool, fluted, so that it has cutting edges all round it. The taper pins are sometimes difficult to remove by blows from a hammer. The hammering rivets over the end, and then the nose or end must be drilled away and the pin punched out. If a new boss is required to be fitted on, fresh holes must be drilled through both boss and shaft and reamered out and pins fitted. The two holes may, however, seriously weaken the shaft.

If a Key Gets Loose, the best way is to fit a new one, but old keys may be made to hold by packing up in the key-way. A piece of thin watch spring of the width of the key is the best thing to use. If it is too thick it can be reduced by putting it on the grindstone, taking a much longer piece than is wanted and fixing the long end on a flat piece of wood with wire or by holding it with a hand vice, and grinding down the length necessary. This is only a makeshift arrangement; a new key should be fitted.

DRILLING HOLES AND REAMING.

The Reader Must Understand that in the manufactory key-ways are cut by machinery, either by slotting machines or by slot drills. Slot drilling is done in a drilling machine. A flat drill without any point is used. The work, which is secured in a movable vice, is worked backwards and forwards under the drill.

The Steering Gears of Cars often get loose through wear of the pins and eyes. As there is no means of adjusting these joints, new pins must be turned up and put in. The pins when taken out will be seen to be worn and the eyes oval (Fig. 22).

If the Reader Has a Stock of Reamers, the best way is to reamer the holes out. They can be filed out if the holes are shallow, but if there is a deep boss it is almost impossible to get a cylindrical hole. The best way would be to drill them out 1-32 inch larger, or 1-6 inch if much worn, and turn the pins to this size. The pins should be case-hardened.

Great Care Must be Taken in Drilling the Holes that the drill follows the old hole exactly, so that, if possible, the rods and jaws should be drilled together in place. Fig. 23 shows the drill having gone wrong. By far the best way would be to buy a reamer of the size required and make a really good job. Shake or play in the steering gear does not come on suddenly; there would be in most cases plenty of time to procure a reamer from the tool dealer. The reader must not forget when putting in new pins to insert the stop pin in the head or to drill the hole for the split pin for securing the nut. If car builders would take the trouble to bush the steering rods considerable time would be saved in repairs.

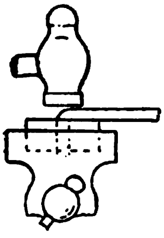


Fig. 24

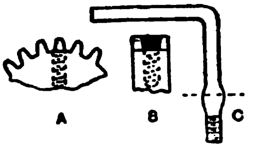


Fig. 25

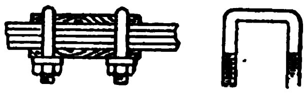


Fig. 26—Spring Clamp

MAKING LEVER RODS.

In Some Cases the Sparking and Connections to the Carburetor Are Operated by Thin Rods Bent at Right Angles at Their Ends. This, to an engineer, seems a slovenly way of doing things, but the system works well. These light rods after a time wear at the joints, and it becomes necessary to replace them. The best way is to put in slightly larger rods, drilling the holes in the levers or bell cranks if necessary. To bend the rods, drill a hole in a piece of flat iron, fix this in a vice, heat the end of the rod—having previously marked the place where the bend is to be—insert the hot iron in the hole.

and bend down, using the hammer to ensure a right angle turn, not a curve. The hole must be bigger than the rod or the hot end would not enter (Fig. 24). The end must be filed circular, for it will be noticed that one diameter is greater than the other. If the rod is too long it may be bent, that is, if the force it has to transmit is small. If too short, it must be drawn out.

FIXING A BROKEN SPRING.

A Clamp for a Broken Spring is a very useful thing to carry (see Fig. 26). It consists of two U shaped iron rods screwed at both ends. The screwing must be done before the rods are bent. The corner where the bends come should be marked with a deep center-punch mark, or they may be marked with a file so that the marks can be seen when the iron is hot. Two pieces of hard wood packing should be placed above and below the spring, and two plates of iron across the springs for the nuts to tighten on. The hard wood packing should have grooves cut in it where the rods come to prevent them working out or the U irons shifting if the nuts got loose. Iron bolts and plates can be used in place of the U irons, but it is not so neat a job.

REPAIRING A TOOTH IN A BROKEN GEAR.

In Many Old Cars the 2 to 1 Gear, which operates the exhaust, has a fibre wheel. Fibre wheels are liable to wear, and a tooth to break out—this sometimes happens with metal wheels. The writer has repaired the fibre wheel by inserting a screwed pin in the place of the broken tooth; it is a simple job that any fairly skilled blacksmith could do if the breakdown happened on the road.

The Tooth That Is Most Likely to Go is the one that is being driven at the moment the exhaust valve begins to lift. The writer, once finding that particular tooth had begun to wear, shifted the fibre ring round its boss, securing it in another position, so that unworn teeth lifted the valve. The wipe contact for the electric connections, being attached to this wheel, had, of course, also to be shifted. Even in metal wheels teeth can be inserted by putting in a screwed peg or stud (Fig. 25). The top of the peg should be flattened out to give more bearing surface. It is impossible to do this after the tooth is screwed in so it should be done before. The stud should be made from a piece of wire or rod bent to an L shape and flattened out at the front to form the top of the tooth. When this is screwed in by means of the bent end, it is sawn across at the dotted lines. If sufficient thread cannot be got in the hole, the peg may be brazed in (see chapter on "Brazing"). The peg must be filed to correspond with the other teeth. Of course, this is only a makeshift; a new wheel should be procured, but this method will often enable a car to run a few hundred miles till the new wheel is secured.

BROKEN STUD OR SCREW.

If a Stud Breaks off close to the hole in which it is inserted—and studs seldom break at any other place—the first thing is to get the broken part out. Put some paraffin oil round the stud to soak into the threads.

If a Piece Stands Up Above the Casting, the stud can sometimes be moved by using a hammer and chisel—not a sharp chisel, as this would at once cut off the projecting part. A diamond pointed chisel is the best to use, as its nose gets a better grip into the metal than a flat or cross-cut chisel would. If the stud will not move, it must be drilled out. In many cases it has to be drilled out in place, and cannot be taken to a drilling machine, and even the swing brace will not turn. A small hole must be drilled down the stud with a hand brace, then a larger one, and a square or triangular piece of steel driven in and turned with the grips. If this fails to move it, it must be drilled out, using a drill that is well under the size of the thread, so that the thread in the casting should not be injured. The hole should be cleaned out with a tap; but before doing this the reader must see that his Whitworth taps, for instance, are the same as the threads in the casting. If the stud is of metric thread, this must be used; or if metric dies are not to be procured, the new stud must be cut up in the lathe. Another way would be to tap out the hole to the next largest Whitworth size and put in a Whitworth thread, but before doing so it should be ascertained that the larger nut will be able to be turned; if not, a nut must be reduced by filing, for most nuts are really stouter than they need be. At the worst a nut could be filed round and tightened with the grips.

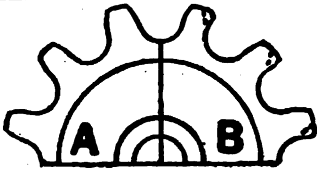


Fig. 1—Fixing a Worn Sprocket Wheel.

In Chain Driven Cars the Teeth of the Sprocket Wheels Become Worn With Use, and after some time, if they are not attended to become veritable hooks, so that the chains will not leave the sprockets without a jerk; this may cause a serious accident by the chain becoming jammed and not leaving the sprocket.

In Fig. 2 the Teeth on the Left Hand Side at A are in their original form; those at B on the right are worn, and being curved will cause the chain to hang, so that the tops of the teeth must be filed away as shown by the dots, to bring them to something like their original state. In many cars with side chains these can easily be filed up in place, without removing the sprockets, but when there is only one chain and a central drive it is almost impossible to do this, and it may necessitate the dismantling of the engine or gear case.

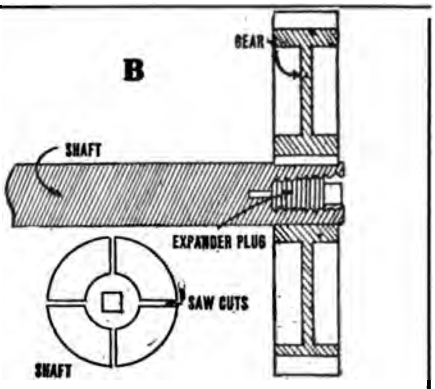


Fig. 2—Repairing a Loose Gear Wheel.

The Gear is Left in place to prevent the shaft turning and a hole drilled in and threaded with a one-eighth standard pipe tap.

The Gear is then removed and the shaft slotted for a distance equal to the length of the hub with a hacksaw, as indicated.

After the Gear has been Replaced a standard pipe plug is screwed in the hole, expanding the shaft uniformly enough to take up all the looseness between it and the shaft hub.

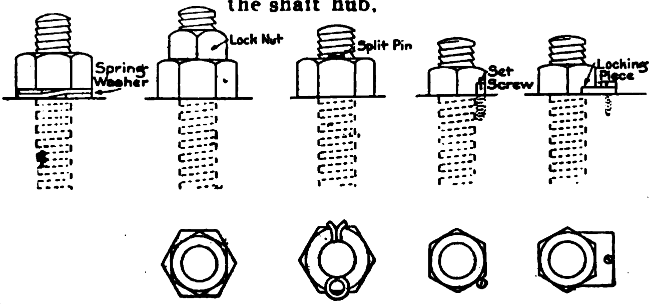


Fig. 3—Different Methods for Locking Nuts. It is important that all nuts on an automobile be locked. The above illustration shows several methods.

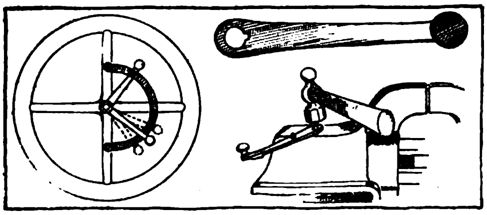


Fig. 4—Showing Method for Tightening a Loose Throttle Control Lever

Remove the lever from the car, place it on the anvil portion of the vise, strike it a few sharp blows with the hammer, as indicated in the illustration, whereupon, on refitting the lever to the end of the rod, instead of fitting loosely, it will be necessary to force it on by tapping it into place with a hammer; the nut then be replaced and the trouble eliminated.

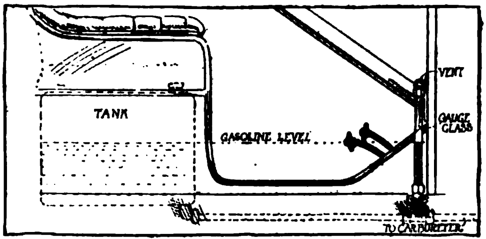


Fig. 5— Showing How a Gasoline Gauge Can be Fitted to a Car

A common ordinary water gauge, such as is obtainable at almost any engineer's supply house, a short piece of copper tubing about the size of the gasoline line, and a T or three-way connection, is all that is necessary. The three-way coupling is used to tap the gasoline line between the supply tank and the carburetor, and a short piece of tubing is used between this coupling and the gauge glass, which can be secured to the dash or side thereof at a height that will indicate at a glance the depth of the gasoline in the tank.

REMOVING A TIGHT SCREW.

The Removal of a Tight Screw Often Presents a Problem. Providing the slot in the screw head be intact, the extra leverage of a spanner applied to screwdriver may have some effect, but the difficulty arises when the slot in the screw head is worn or burred over and practically non-existent. In this case the slot must be recut, and this can be done by means of a very small chisel ground down to a very narrow cutting edge. Sometimes a screw can be started by applying a chisel and giving it a smart tap to the left tangent-wise. A better plan than using copper wire to bind up a frost crack in cylinder jacket is to use a strip-iron clamping band, drawn up tight by a bolt and nut.

TREATMENT OF AN IMMOVABLE NUT.

A Method Worth Trying is that of warming up the nut by pouring a little gasoline over it and lighting it. The result is, in many cases, that the nut expands sufficiently to ease it on the bolt. It is better, if, previous to warming the nut, some paraffin is poured over it and left for some hours, in the hope that some of it may work down the thread.

Steady Application of the Spanner, (if necessary a piece of iron tubing can be slipped over the handle to increase the leverage) should suffice to move the most refractory nut. Another plan, but a rather risky one, is to get a bar of square steel, about the same depth of the nut, and have the edge of this held by an assistant against the side of the nut, then give the end several blows with a hammer, so as to apply the force tangentially.

A Nut May Defy All the Usual Methods to Loosen, such as extra long spanners, oil, heat, chisels, etc., all without result. Evidently, in this case the nut has become securely rusted on the thread, and the only result of extreme force would be to twist the bolt and probably break it off.

The Proper Course Is the rather drastic one of splitting the nut on one side, thus springing it open, when it can easily be removed.

With An Ordinary Geared Hand Drill, and a sharp bit a couple or more holes are drilled down from the upper face of the nut and so close together that, by means of a chisel, they can be cut through.

Providing One Can Conveniently Manipulate the Drill, the operation should not take many minutes to perform. The bolt, of course, is not injured in the process.

A STRIPPED NUT.

One of the Most Annoying Experiences Is to Have a Stripped Nut which one cannot conveniently replace.

It Is Usually a Special Size Nut with fine thread which goes wrong.

A Method that may be adopted is to reline the nut uniformly with soft solder and then give it a start on the bolt, and by working it down the thread a little at a time cut a new thread inside the nut.

The Soldering Part of the Operation is simple enough, the nut being fastened to a piece of iron wire, dipped in the killed spirits, and then held in the blow-lamp till hot enough to melt the solder.

The Same Process reversed would apply equally well to a stripped bolt and the nut used to cut a new thread on it.

GASOLINE FEED PIPE CONNECTION. (See Chart 154.)

Quite Often the Nut Is Tightened Up cross-threaded and the pipe leaks. Always be careful on making good straight connections, especially on the gasoline line.

FITTING A MUFFLER CUT OUT.

Mufflers Sometimes Are Not Large Enough and offer "back pressure" or resistance to the full passage of the exhaust.

Muffler "Cut-Outs" Are Installed by cutting a hole in the exhaust pipe just ahead of the muffler, and is a help in climbing hills and also to keep engine cool if it has a tendency to heat.

FITTING AN EXHAUST WHISTLE.

The Exhaust Whistle is becoming quite popular and is blown by the exhaust pressure.

When Fitted to an Exhaust Pipe the exhaust is temporarily cut off from the muffler and thrown into the whistle by a special valve attached to the exhaust pipe. (Fig. 5.)

Multiple Engines blow a whistle almost steady, but single and double cylinder engines blow in jerks or uneven.

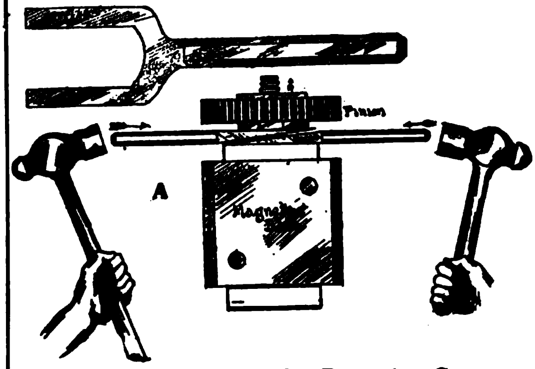


Fig. 1—A Special Tool for Removing Gears Especially adapted for removing magneto gears on a tapered shaft.

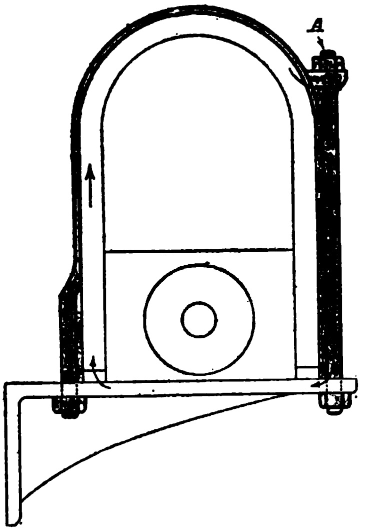


Fig. 2—One Method for Fitting a Magneto to Engine Frame

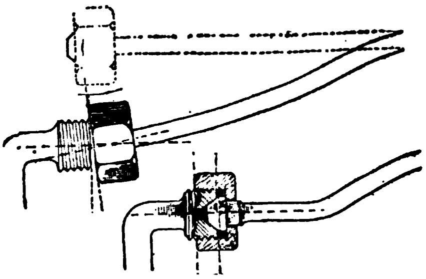


Fig. 3—A Gasoline Feed Pipe Connection

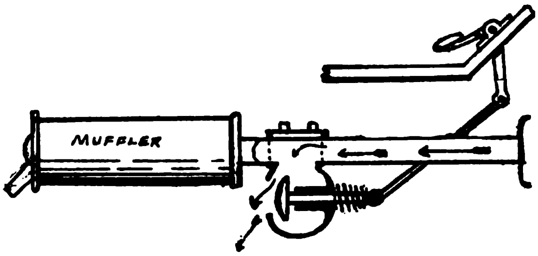


Fig. 4—Fitting an Exhaust "Cut Out"

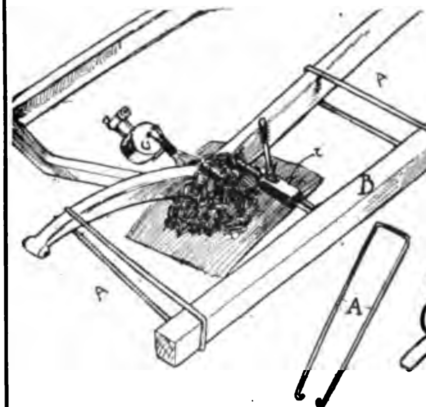


Fig. 6—Straightening a Bent Frame

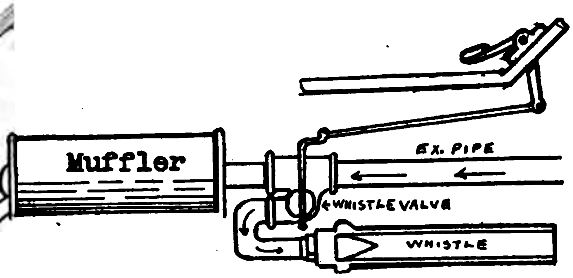


Fig. 5· Fitting an Exhaust Whistle

CHART No. 154

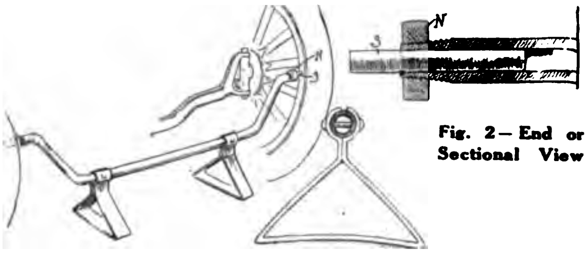


Fig. 2—End or Sectional View

Fig. 1—Illustrating the Home Made Device for Lining Up the Front Wheels

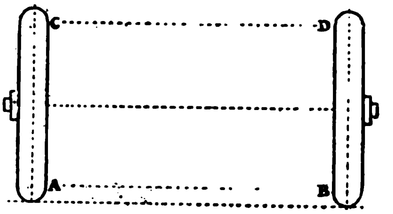
ALIGNMENT OF FRONT WHEELS.

It Is Not Generally Known, Perhaps, That Excessive Tire Wear Often Is Caused by Improper adjustment of the cross link of the steering gear. A point in connection with this adjustment is that which is termed foregather. In order that the front wheels of a vehicle run and steer properly, the cross-link of the steering gear should be adjusted so there will be about ¼ to ⅜ inch foregather present.

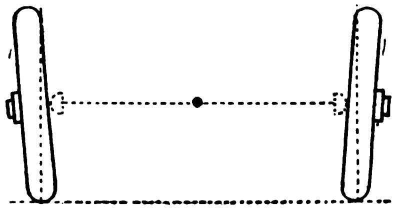
This means that the foremost points of the wheel felloes should be from ¼ to ⅜ inch closer together in front than the hindmost points of the wheeled felloes. In Fig. 1 and 2 is shown a simple home-made device used for testing and adjusting the wheels of cars for proper alignment.

It Comprises a ½-Inch Piece of Gas Pipe, bent as indicated, and mounted upon legs, formed from band iron about 3-16 inch thick and ¾-inch wide; these legs are formed and secured to the pipe with a pin, which is riveted at both ends, as indicated at A. The ends of the pipe are threaded with a tapered thread and slotted longitudinally and a Nut, N, is provided to fit the thread. A rod, S, about 6 or 8 inches long and of such diameter that it normally will slide freely in the pipe, is placed in each end to render the ends adjustable, and when the nuts are drawn up on the tapered thread these rods are secured in place.

To use this device the wheels are set for a straight forward direction, and the device placed in front of the axle as shown; then the ends of the device are adjusted so that they just touch the felloes at their foremost points. The adjustments are secured in this position and the device is moved to a similar position behind the rear axle; if the alignment of the wheels is correct with one end of the device touching one of the felloes, the other end will lack from ¼ to ⅜ inch of touching the other felloe.



Properly Lined Up Wheels, Distance A to B and C to D the Same



Improperly Lined Up Wheels—Hard on Tires

LINING UP THE FRONT AND REAR WHEELS.

This is another fault which may arise. The front and rear wheels may not track with each other.

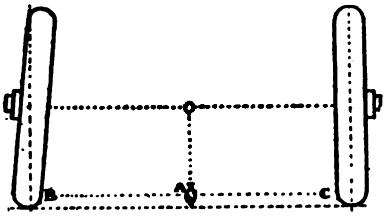
On chain-driven cars an arrangement is always provided to adjust the tension of the chains equally by means of an adjustable stay or bar at the ends of the axle.

Unless considerable care is taken when adjusting these stays, the axle may not be dead at right angles to the frame of the car.

This will be very bad for the tires, and also for the chains and chain sprockets.

Here again the Alignment test can be applied, a long straight edge being laid across the outside face of the front and rear wheels. If both sets of wheels are in track, the straight edge (or stretched cord) will just touch equally at the four positions.

In a case where the front steering wheels are canted, the test should be made rather low down.



Another Poor Alignment of Wheel

The same fault would be indicated by the car leaving two distinct sets of tracks behind it when running on a wet road.

It will be obvious that the front wheels make one track and the rear wheels another.

A piece of chalk held close to the edge of the rim whilst it is spinning will rub at some points and not at others.

This test should not be made on the side of the tires, but on the rim, because tires are not always moulded dead true, may not have been adjusted to the rims quite accurately, or a detachable non-skid may have been fitted, and these often give the wheels a slightly "wobbly" appearance, although the wheels may be quite true.

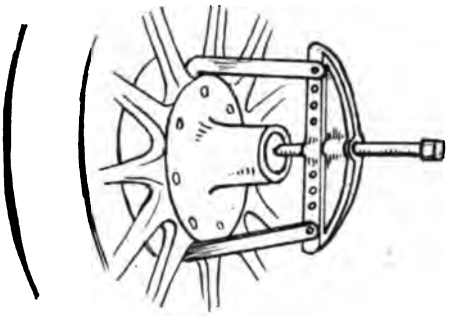


Fig. 1—A Wheel Puller

Pulling a wheel from a rusted axle is a bigger job than it appears. If the axle is greased before the wheel was put on the probabilities are it will come off readily, if not it will, more than, likely be a task. A wheel puller can be bought of any auto supply house or one can be made by local blacksmith. Every repair shop needs a wheel-puller.

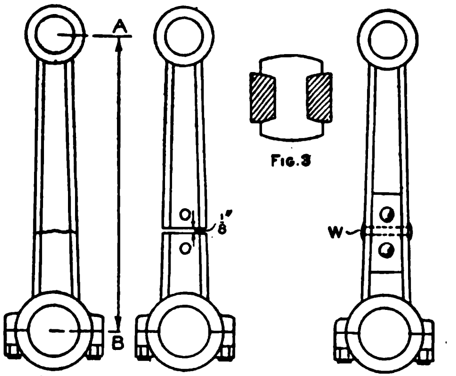


Fig.1 Fig.2 Fig.4

Repairing a Broken Connecting Rod

One of the Connecting Rods on an Automobile engine broke, as shown in Fig. 1, and the repair was made in the following manner, which has stood the test of daily use for a year. The broken parts were placed together and the distance from A to B accurately measured. Both ends of the parts were filed off flat and smooth. This made a space of ⅛ in (Fig. 2) to be filled with a wedge.

A Hole for a Rivet Was Drilled in the Channel About ½ in. from each end and ⅛ in machine steel side plates fitted as shown in Fig. 3. Holes were drilled in the side plates so that when they were riveted in place, the connecting rod was about 1-32 in. short. The wedge W, Fig. 4, was driven into the space between the ends and riveted to keep it in place.

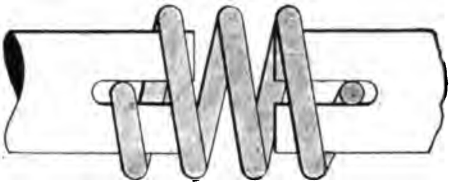


Fig. 2—A Flexible Pump Shaft Connection
The ends of shaft are slotted and a helical spring having ends of wire bent as shown.

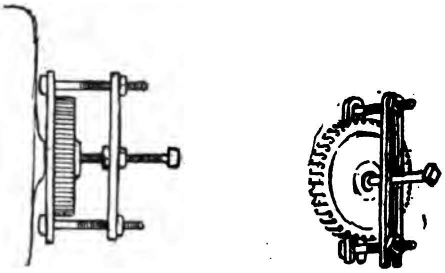


Fig. 3 Fig. 3A

A Gear Wheel Puller

As illustrated in Fig. 3, a timing gear is being removed from the end of the crank shaft of a motor.

In This Case only two of the U pieces are brought into service, the sides of the piece in back of the gear being of exceptional width so that it could clear the boss on the end of the crank case and the shoulder of the gear.

These U Sections are so easily made that quite an assortment may be had at a very small cost.

In Removing a Timing Gear, as shown in Fig. 3, after having assembled the parts into position as illustrated, it only is necessary to hold the nut on the center bolt with one wrench and screw it on the center bolt with another.

When Using a Device of This Kind for pulling road or gear wheels, etc., some care should be exercised in fitting the parts together so that the side bolts are both adjusted to the same length in order that the strain be equally distributed when the center bolt is screwed up.

When a Fairly Stiff Strain Has Been Put on the Center Bolt of this or any other kind of a wheel-puller, and the wheel refuses to yield, one or two sharp taps on the top of the head of the center bolt may start the wheel on the shaft.

These U-Shaped Pieces, together with bolts of different lengths and washers, are extensively used by the machinest for clamping articles to the face plates of lathes and drill-presses and the like.

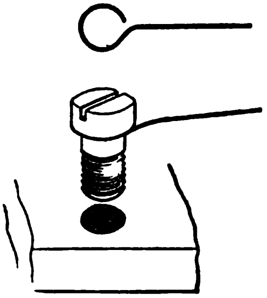
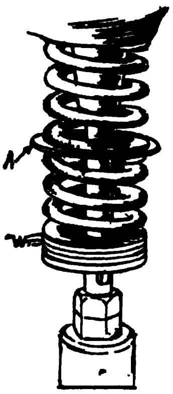


Fig. 4—A Simple Method for Inserting Screws in Inaccessible Places



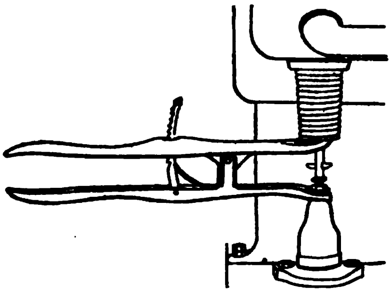


Fig. 1—A Valve Lifter

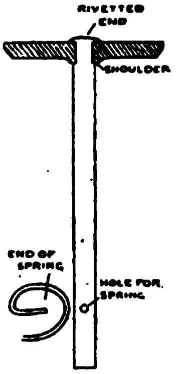


Fig. 2—How to Strengthen a Weak Valve Spring

It sometimes occurs that the valve springs of a motor will become weak and give considerable annoyance before the cause is discovered. Springs too weak to hold the valves on the cams will produce clattering noises owing to belated seating of the valves.

***The best way to increase the spring tension** on a valve is to fit a new spring, but if a cheaper method is desired one has but to stretch the spring a mere trifle by slightly opening up the coils with a screwdriver or by securing one end coil of the spring in a vise and tieing a cord or the like onto the other end coil to get a grip and then stretching it a little in the ordinary way.

Another way to increase the tension is to place a couple of washers under the lower end of the spring as illustrated at W.

It has been suggested that if a spring should break on account of a defect in the material or heat treatment, a temporary repair might be made with a washer as shown at A.

Valve springs that are too stiff are to be avoided because they may close the valves with so much force as to break the stems at the key, or the heads from the stems, and even if the valves do manage to stand the constant hammering action, an excessively stiff spring consumes power which might be used to a better advantage.—(Motor Age)

Fig. 3—How to Put a New Head on a Valve Stem

It is rare nowadays to be completely "cornered" with broken exhaust valves, but at the very worst, if one had the valve head intact, it could be fitted on a new stem.

A Piece of Mild Steel rod about the size of the stem required is necessary.

The head of the valve is filed down to allow of drilling exactly central rather smaller than the stem; this latter should then have a shoulder filed at one end to drive very tight through valve head and project through a full ⅛ inch, so as to allow a riveting over securely.

Instead of having to cut a slot in the stem to take the cotter in the ordinary way, a small hole can be drilled through the stem and the end of the spring hooked into it.

The end should be softened in a flame and bent at a right angle.

The cutting of a slot is not an easy process, whereas the end of the spring may, with a little persuasion, be made to enter the hole, and it works just as well.

With a built-up valve, such as described, it is necessary to allow a good clearance at the tappet, because after a short time the head will probably draw away from the stem a short distance, and if the tappet be set too close the valve will remain open.

If the stem be screwed into the head tight and then riveted over, the head cannot shift, but one may not have screwing appliances convenient.

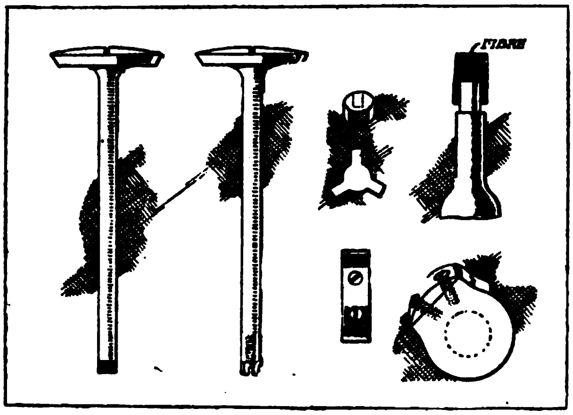


Fig. 4—Lengthening a Valve Stem. The illustrations depict: Valve stem lengthened by having a piece of steel brazed or riveted on. Another method: a steel screw fitted into end of valve stem which is suitably drilled and tapped. Cap made from sheet steel to fit over top of valve tappet for taking up clearance. Cap turned from bar steel fitted with fibre inset for silent working. A method of renewing a worn cam: a piece of steel trimmed to shape first soldered on, and then drilled and tapped as shown; afterwards it is unsoldered and hardened and screwed in position. Fitting a new complete cam is always best when practicable.

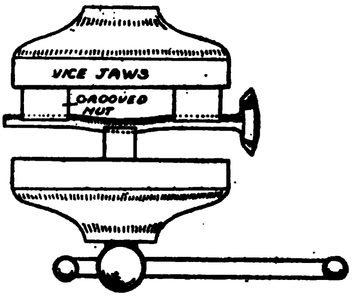


Fig. 6—Method of straightening a bent shaft or rod such as a valve stem. The vise is used as a lever. The supports are grooved and adjusted to suit the bend.

FASTENING A MAGNETO.

Locating the Magneto by Means of Pins and holding down on its base by a strap of metal passing over the magneto is a favorite method.

The Band Is Usually in Two Sections, as illustrated in Fig. 2, thus bringing the nut A, which tightens or loosens the band, at a point which is easily gotten at.

In Other Instances, however, the magneto is bolted direct to its base and, since the nuts are below, it is almost impossible to remove the magneto after the engine has been placed in the chassis.

It Might Also Be Worth Mentioning, at this point, that some magnetos are strapped down on iron or steel brackets and no precaution taken to see that brass or non-magnetic fittings are used at the point "A," where the tightening bolts joined the straps.

A Little Thought will show that, as illustrated, a portion of the lines of force will return by way of the bolts and base instead of through the armature.

Although the Effect of this May Not be Noticed at Ordinary Speeds, it will have much to do with determining the lowest speed at which a good spark is produced.

STRAIGHTENING A BENT FRAME. (See Fig. 6, Chart 154.)

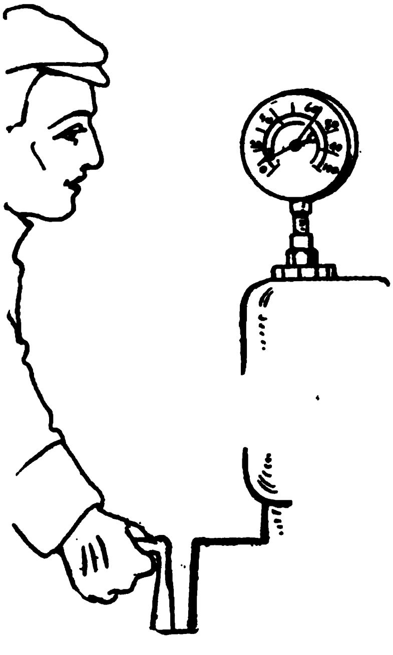
To Make the Repair, the radiator was removed, a pan of charcoal was placed under the frame, and pieces of charcoal heaped up around the bend as designated; the frame was then heated up about the bent portion by playing upon the pile of charcoal with the flame of a blow torch.

As the Frame Was Brought to a Cherry-Red Heat the tool A was applied to the frame, and used in connection with a wooden beam B which supported the jack J.

The Torch Now Was Set Aside, the charcoal removed, and while one man carefully operated the jack and slowly drew the bent member back to its proper shape, another deftly assisted the operation by tapping and contouring the heated section with a hammer.

This Hammering Is Quite Necessary and an important factor in bringing about a successful result as it assists the molecular action of the steel, and prevents the end of the frame from springing back out of line as the job cools off.

The Entire Straightening Process must be done while the injured section is red hot and the job completed before the red color is lost.



OVERHAULING AN ENGINE.
INCREASING THE POWER.

To Increase the Power of an Engine, and to overhaul it means careful study. One simple remedy may be all that is necessary, yet again the engine may need all of the usual treatments as follows:

Putting the compression in good order by grinding valves and making the rings tight.

Cleaning the carbon deposit.

The valves may not be set right and need re-setting.

The valve tappets may need adjustment.

The bearings may need attention.

All of the Above Will be Treated Separately. There are several reasons why an engine loses power, and a person must take the time and properly diagnose the case on hand.

IF ENGINE LACKS POWER, SEE TO THE FOLLOWING.

Compression and Ignition in Good Order and capable of sufficient advance for obtaining the utmost power.

Muffler free and of good design.

Exhaust and Inlet Piping large enough and free from sharp bends.

The Valves lifting sufficiently and correctly timed.

Cams of Correct Shape and not worn.

Carburetor supplying a proper mixture.

Lubrication of engine adequate.

No Binding in Transmission and same properly lubricated.

Brakes not rubbing

Gear ratio to rear axle not too high, particularly the lowest gear.

Road Wheels not out of track.

Engine not overheating or running too cool.

See that all Bearings are tight in engine.

See That There Are no **Leaks** in valves, piston rings or various pipes and parts. Muffler of large dimensions and free from "back pressure."

See That the Timing Gears and cams are properly set.

See That There Are no loose parts in engine.

If Any of the Above Factors Can Be Improved, a very noticeable increase of power may be secured; for instance, fitting a new and improved carburetor or muffler will sometimes work wonders.

"LOSS OF COMPRESSION" THE USUAL CAUSE OF LACK OF POWER. ....

If After a Test, the Above Troubles Are Not the Cause, then the probabilities are the cylinders are losing compression. (See page 114.)

The Loss of Compression Means, that the charge of gas drawn into the cylinder during the suction stroke escape from the cylinder when the piston travels back in the next stroke up, which is called the Compression stroke.

This Leak May Be Caused from various sources as follows: Through the intake or exhaust valves, through the piston rings, through the threads of the spark plugs, if not screwed into cylinder tight. Sometimes there is a sand hole in the piston too small to be detected by the eye, but when the pressure is exerted on the end of the piston, the gas passes through. Sometimes there is a sand hole in the cylinder.

HOW TO TEST FOR A COMPRESSION LEAK.

The Test for the Above Causes, is to first test and see if the valves and piston rings leak.

This Is Best Done after the engine has run awhile, because it is warm inside the cylinder, and the leak can be found easier.

The Usual Method Is to Open All the Pet Cocks or Relief Cocks on top of the cylinders, except the one being tested; then turn the crank slowly, and see if this cylinder holds its compression, if the cylinder turns over, first with a slight pull against compression, then the pressure gradually lessens, then you may know that the cylinder is not holding its compression, and that it is leaking, and the leak must be found and remedied, because the gasoline engine depends on its compression to deliver its maximum power just the same as a steam engine requires its pressure of steam to enable it to deliver it's full power.

EACH CYLINDER MUST BE TESTED SINGLY.

Each Cylinder Must be Tested Singly, and in the same manner and a note taken of the cylinders which turn over easy.

There Is No Fixed Rule to Tell Exactly How to Test a Cylinder in This Manner, but after a little practice, cranking the engine, the motorist will be able to "feel" the compression, that tells which cylinder holds and which cylinder does not.

FIRST SEE IF THE LEAK IS PAST THE PISTON RINGS.

In Order to Find Out Just Where the Leak Is, first try the piston and see if the gas is escaping through the rings into the crank case.

This Can Best be Accomplished by removing the crankcase cover plate adjacent to the cylinder in question, after which pull the crank up so that the piston shall be at the inner end of its compression stroke, and listen for a bubbling sort of hiss in the crank case.

There Is No Mistaking This Sound, since the crank chamber acts as a resonator, and even the slightest leakage is distinctly audible.

If the Sound of Gas Escaping Past the Piston endures for an appreciable time, upward of a minute or so, the chances are that the use of an oil of slightly greater "body," for cylinder lubrication, will cure the fault.

However, If the Escape Is of Short Duration, the matter is more serious, involving as it may a cracked piston, scored cylinder walls, or broken, warped or gummed rings.

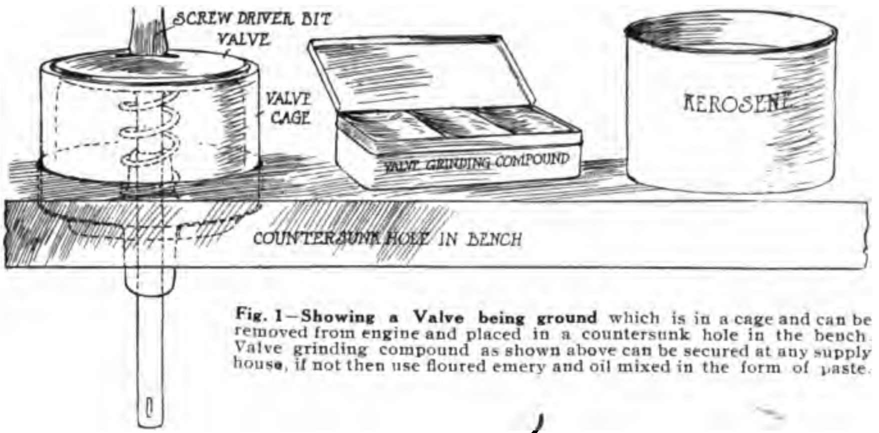
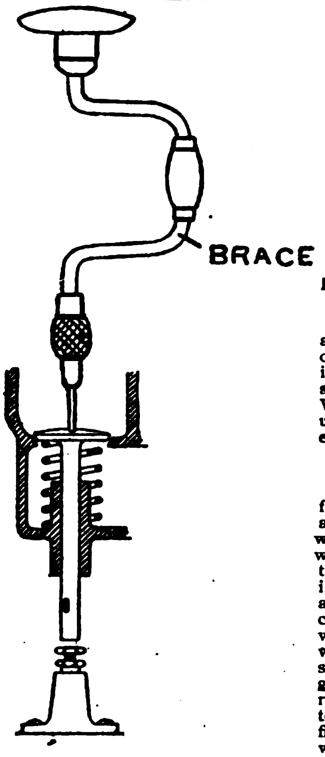


Fig. 1—Showing a Valve being ground which is in a cage and can be removed from engine and placed in a countersunk hole in the bench. Valve grinding compound as shown above can be secured at any supply house, if not then use floured emery and oil mixed in the form of paste.



Fig, 2—Method of Grinding-in a Valve Where the Seat is Not Removable. It will be noted that a small, light spring is placed temporarily under the valve head, the purpose of it being to lift the valve from the seat when the pressure of the brace or screwdriver is occasionally released. This prevents scoring of the surfaces or formation of ridges by the abrasive material. An ordinary screwdriver may be used, but a brace saves time. Before grinding in the valve should be examined to see that it is quite true. The stem may be slightly bent and require straightening. If the valve head is deeply pitted it should be refaced with a valve face trimmer.

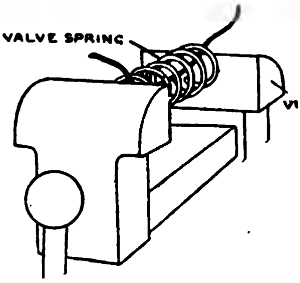


Fig. 3—Tie the Valve Spring Before Trying to Replace it

Simple method of compressing a valve spring between the jaws of a vise Whilst compressed it is tied up with a loop of wire or string in two or three places When the spring is thus tied up under tension its replacement is easy.

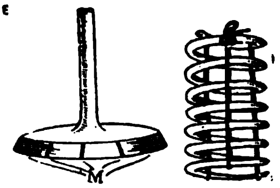


Fig. 4 To Test the Finish o a Valve Stem

Mark it as shown with a lead pencil, about 1-2 inch apart or less; after putting valve in place and oscillated about 1-4, if all marks are erased the job is satisfactory. (The marks on valve "M" are the pencil marks to be erased)

HOW TO GRIND VALVES

The Valves Should be Removed one at a time and ground in as follows; Should the motor be an L or a T-type, remove a valve and plug up the opening between the cylinder and valve chamber with a bundle of cloth, having previously tied a string to the cloth which is attached to some external portion of the motor, or raised the piston to the top of the cylinder, so that the cloth will not fall into the cylinder. This is to block up the entrance to the cylinder and prevent emery from getting in and scoring the walls of the cylinder and piston. If the motor is a valve-in-the-head type, with the valves contained in removable cages, these precautions will not apply. If emery and oil is to be used in preference to the specially prepared valve-grinding compounds on the market, to grind in a valve which is badly pitted it is well to begin with rather a coarse grade of emery. Apply a coat of cylinder oil to to the face or seat of the valve, distributing it with the tip of the finger; then dip the oily finger into the emery and apply that which adheres to it to the seat on the valve Be careful to keep the stem of the valve clean, so the guide will not be enlarged.

Turn the valve about a half revolution back and forth on its seat in the cylinder or cage and occasionally lift the valve from its seat and shift it around.

When the pits are almost removed, continue the operation with flour of emery instead of the coarser grade: remove the valve oftener, applying more oil and less emery each time, until a good seat is obtained all around; then finish up by polishing the seats with oil. Kerosene is most effectively used in finishing the seats of a valve. and the smoother the finish obtained the less chance for a carbon deposit.

In the illustration, fig 1, is to be seen the valve grinding outfit used in a factory where valve-in-the-head motors are made At the right is shown a can of kerosene into which the valve-and-cage unit is dipped at frequent intervals; in the center is a box of specially prepared valve-grinding compound containing coarse, medium and fine grades; and at the left is shown the valve and valve-cage resting in a counter-sunk hole in the bench with a spring under the valve to raise it. This means of supporting the valve cage permits of the use of a brace and bit or breast drill to facilitate and make easier the valve-grinding operation.

* See Chart 157 showing a valve lifter which can be secured at any auto supply house.

ANOTHER METHOD.

Flush Out the Cylinder Combustion Chamber With an Oil-Gunful of Gasoline, making no attempt to fully remove the liquid.

Again Pull the Piston to Inner Dead Center, and, with the aid of an electric lamp and a small mirror, observe the bubbles caused by the escape of the gas about the lower edge of the piston.

There Will Naturally be no Bubbles, at this point, if the piston head is fractured, but it may be possible to see the crack through which the leakage occurs. At any rate, if enough gasoline has been left in the cylinder, one will be able to see it trickling down the connecting rod or inner piston walls, should such a crack exist.

If the Cylinder Walls are Scored, one will see the liquid at but a few points about the lower edge of the piston, and, as the gasoline washes the oil away, possibly the score marks also.

In Case the Trouble Is With the Rings, the bubbles will be more evenly distributed about the periphery of the piston and will be all of about the same size.

Should This Latter Condition Obtain, the use of a kerosene injection, about an ounce each night after running the car into a garage, for a few days will in all, probability eliminate the leak if the rings are only gummed.

If This Latter Is Not Effective, the job is one for the repair shop.

If the Gas Is Escaping Through the Rings then it will be necessary to take off the cylinders and look at the rings.

If There Is a Black Spot on the Rings, it is evident that the gas has been escaping at this point.

The Method for Treating Rings is shown in chart 159.

NEXT, SEE IF THE VALVES LEAK.

If the Rings are Remedied, or are tight in the first place, then the leak must be in the valves, in fact it is quite often the case the leak is in both valves and rings.

After the Rings Have Been Made Tight and There Is No Leak In the Rings the valves must be tested by cranking the engine as stated before and each cylinder tried out for compression again. If the valves leak the cylinder will not hold its compression and it is advisable to grind the valves as shown in chart 158.

Sometimes There Will Be a Discharge Back Into the Carburetor, this indicates a leaky intake valve.

Sometimes a Discharge In the Muffler indicates a leaky exhaust valve.

MAY BE A LEAK THROUGH A SAND HOLE IN THE PISTON OR CYLINDER.

If After the Piston Rings Have Been Remedied and the valves ground and the compression is still weak, then the probabilities are the valves are not set just right or there may be a leak through a sand hole in the piston or a crack in the cylinder.

These Should Be Examined When the Cylinders Are Off and the rings are being fitted.

HOW TO TEST FOR A SAND HOLE LEAK.

If a Hole Is Suspected a test can be made on the cylinder to see if there is a leak by putting a foot pump connection to the water jacket of the cylinder, fill water jacket with water and apply the air pressure and see if bubbles of water ooze through, inside of cylinder. If this is the case then these holes must be made tight.

It Is Possible to Stop These Leaks sometimes by the sal ammoniac treatment as explained on page 450.

If Water Is Found In the Crank Case, it is evident that there is a leak.

The Power of an Engine Depends Upon Good Compression and good compression must be maintained.

A KEROSENE OIL TREATMENT IS SOMETIMES SUFFICIENT.

I Have Known Engines to Lack Power from merely the rings becoming gummed up.

This Trouble Can Be Remedied by first running the engine until it is warm, then stop it and drain out all the oil, then take out the spark plugs, fill each cylinder full of kerosene by pouring the kerosene through the holes.

Plug Up the Spark Plug Holes With Old Plugs and then crank the engine several times by hand so that the oil will work its way down around the rings, leave this oil in overnight and next morning crank the engine quite a number of times until you think the oil has passed into the crank case and out of the cylinders through the exhaust pipe, in other words get the oil out of the engine. Drain the crank case. After draining crankcase and putting in lubricating oil, start the engine. The engine will smoke considerably to begin with, but this will soon pass away. This will not only loosen up the rings, but will also clean any carbon that may have become deposited in the combustion chamber. This treatment oftentimes saves the trouble of fitting new rings, and in some instances will make a marked difference in the running of the engine.

PISTON RING TROUBLES.

It Is Not an Unusual Experience to Find a Set of Piston Rings Possessing a Peculiar Weakness for Working Around the Grooves till the slits arrange themselves more or less in line. The writer came across a motor which had the slits of the rings very carefully spaced out a couple of months previously; yet when the cylinder was taken down, all the slots of the rings were close together.

It Is a Common Belief that if the slits come in line an escape of explosion pressure from the combustion chamber to crank case is bound to occur. This is not necessarily the case.

It Must Be Remembered that if the rings are made the correct size the ends should close up, certainly to within 1-64 of an inch, when the ring is in the cylinder.

There Is Not, However, much of a passage for an escape of gas; and then there are the walls of the other grooves interposing between the slits.

If the Ends of the Rings Do Not Meet, then a leakage of some consequence may occur. The piston itself does not make as close contact with the cylinder bore as the rings; hence if there is an appreciable width of slit existing in each ring, it is not difficult to see that some of the high pressure gas might worm its way past the crank case.

It Is Rather a Puzzle Why the Rings Should Move Round At All. One Theory Is that the explosion communicates a very minute (almost imperceptible) rotative movement to the ring, and a slight escape occurs to the others, and so on, the path of escape tending to shorten itself.

The Slacker the Rings are in the grooves, the more rapid the movement, as the alternate rocking or tilting movement occurring on each stroke would accelerate the creeping action.

An Alternative Theory suggests itself—namely, that the cylinder bore is not perfectly circular.

With the Usual Eccentrically-Turned Ring, the thin part being slotted, there will always be a tendency for this part of the ring to accommodate itself to the widest diameter of the cylinder.

PINNING THE PISTON RINGS.

If It Is Found Necessary to Pin a Set of Rings it is the best plan to arrange the pins 120 degrees apart, and then very carefully notch the ends of the rings with a very small round file, so that the semi-circular notches just close over the pins.

Care Should Be Taken that the pins are screwed tightly into the piston and do not stick out as far as the surface of the piston, since they would be very liable to damage the cylinder bore.

As Regards the Fit of the Rings in the grooves, they should be just a free fit, neither tight enough to jam nor slack enough to rock.

Tight Rings May Be Eased by Grinding one of the edges on a sheet of fine emery cloth fastened to a piece of board planed quite flat. The ring is gently rubbed backwards and forwards with a downward pressure.

After Long Periods of Running, a deposit of charred, or partially charred lubricating oil is liable to form behind the ring and interfere with its free movement; it is a good plan, therefore, when overhauling the motor to slip off the rings from the piston and thoroughly clean out the grooves with a sharp bit of metal.*

REMOVAL OF RINGS.

The Removal of Rings Is Not Difficult if a little forethought is taken: to open them it is best to use a pair of very thin jawed pliers, the jaws opening outwards, a substitute for pliers can be made from iron wire. (See Fig. 7, Chart 159.)

When the Ring Is Slightly Expanded, a narrow slip of very thin metal—tin or brass will do—should be pushed through the opening and worked to the opposite side of the slot; then if the ring is opened a trifle more an additional slip of metal can be placed near the ends of the ring, when it can be worked off quite easily and without any risk of breaking it, such as an attempt to expand it larger than the piston diameter would do.

It Is a Good Plan to Mark Each Ring for its own groove, and also when they are not pinned to mark just where the slots should come on the piston.

Although It Is Not Wise to Take an Engine to Pieces unless it is suspected that there is really something radically the matter with it, yet when there is a decided loss of compression which is not immediately cured by the regrinding of the valves, it is well to take off the cylinder which is at fault and make a complete examination of the piston rings.

FITTING PISTON RINGS.

Like All Other Mechanical Operations, the Fitting of Piston Rings Is Comparatively Simple—If You Know How; but in the hands of the novice many are sprung and some are broken.

Most Manufacturers, of which Mitchell is one, now cut the grooves in the piston , and grind the face and edges of the rings to a gauge, making very little hand-fitting necessary. But there are cases, and these are the ones that generally come into the repair shop, where the cut was just a trifle larger, or the ring a little smaller than the gauge, making it essential that each ring be individually fitted to the groove in which it shall subsequently rest.

To Properly Dress Down a Ring Requires Some Skill, and a good mechanic will select a ring which will demand the least amount of trimming, for it is a delicate operation.

After Having Selected a Set of Rings, the first operation is to fit them into the cylinder.

Taking One of the Rings, try very carefully to shove it straight in, concentric with the cylinder walls; if the ring is of the diagonal-slot type and its diameter a little large, the ends will run upon each other, throwing the edges out of line; while if a ring with a square-cut overlapping ends is used, such as is to be found in the Mitchell motor, it will not go in at all.

Therefore, the Ends Must Be Trimmed Off So That when the ring is well up into the cylinder there will be a space of about 8 to 15-1,000 of an inch between the ends, to allow for expansion caused by the heat of the motor. The groove on the block shown in Fig. 1 is used in reducing the size of the diameter of diagonally-slotted rings.

A Thin, Smooth, Flat File Is Best Used for This Purpose and it should be placed between the ends of the ring with its bottom edge in the groove. The ring must then be pressed together so that its ends bear against the surface of the file as it is moved forward.

The Ring Should Be Repeatedly Tried in the Cylinder in Order That the Space is not filed to exceed the above dimensions.

The inside portions of the rings near the ends should rest against the nails, in order that they may not be broken off when filing the slot. Having attained the proper space between the ends of the ring, now place a light in the cylinder behind it and see how its face conforms to the wall of the cylinder.

---

*Kerosene injected into the cylinder through the compression cocks occassionally after a run, when engine is hot, and left over night, will have a tendency to loosen up any gum formed under the rings and will also dissolve any carbon or soot on piston.

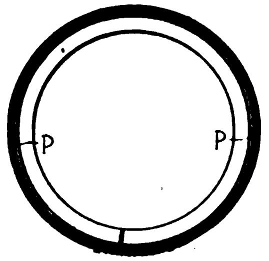


Fig. 2—Cylinder Out of Round

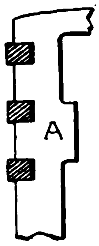


Fig. 2A—Propely Fit Rings

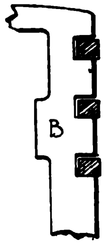


Fig. 2B—Improperly Fit

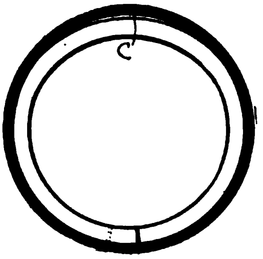


Fig. 2C—A Sprung Piston Ring, See C

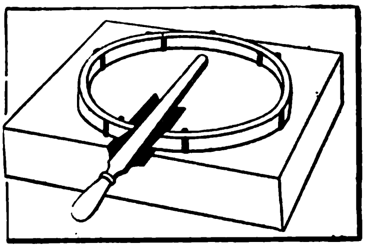


Fig. 1 —Means of Holding a Piston Ring to File it

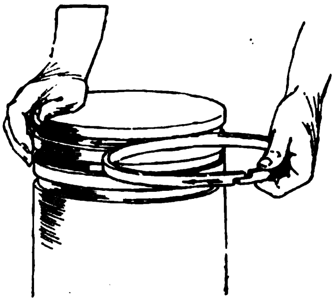


Fig. 3—Trying the Rings on a Piston

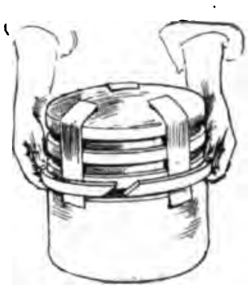


Fig. 4—One Method of Slipping a Ring on a Piston

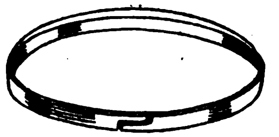


Fig. 5—Piston Ring with Stepped Joint which prevents leakage of pressure at the joint.

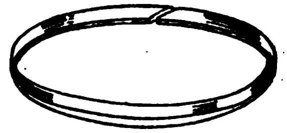


Fig. 6—Piston Ring with Joint Cut Slantwise. Easier to make than the other type. but not quite so effective in preventing possible leakage.

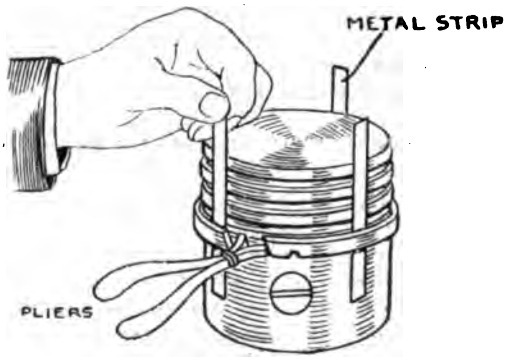


Fig. 7—Another Method of Removing Piston Rings From Piston Grooves. The ring is expanded slightly by special pliers or tongs. Strips of metal are then inserted under the ring at equidistant points, when the ring can be safely slid off. In replacing the rings the middle one is first fitted on over the strips, and then the other two.

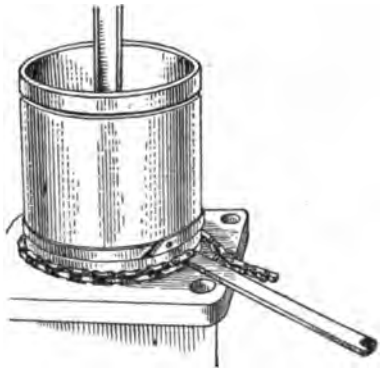


Fig. 10—A Home Made Tool for Holding Ring in the Groove until the cylinder is slipped on. Sometimes a string or copper wire is wrapped around each ring until the cylinder is pushed over the ring and the string or wire is slipped off as the cylinder goes on.

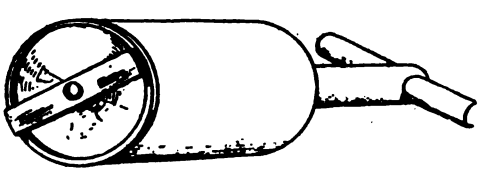


Fig. 8—A Handy Device for Testing and fitting the piston rings in cylinder. This device consists of a round block of wood with handle on one end. The piston ring is placed on the other end and is placed in the cylinder and worked back and forth.

CHART No. 159

If There Is Good Contact All Around, the ring is ready to be fitted to the piston; but if the contact is poor, either the ring or the cylinder is out of round, leaving space between cylinder wall and the ring as at C and P in Fig. 2 and 2C.

If the Fault Lies in the Ring the face can probably be dressed down to fit, or another selected; but if the cylinder is badly out of round it will have to be rebored or reground, or both, as the case may be, or replaced with a new cylinder.

When the Rings Have Been Adapted to the Cylinder, the next operation is to fit them in their respective grooves on the piston.

Begin With the Ring Selected for the Bottom Groove, so that ring will be the first to be slipped onto the piston.

First Try the Ring Without Slipping It Over the Piston by Inserting It In the Groove and rolling it around its circumferenee, as indicated in Fig. 3.

It Should Fit Snugly, as at A, Fig. 2A, but still be free to slide in and out easily; if it binds in any place, apply a thin film of red or black lead or prussian blue in the same manner as used in scraping bearings, to locate the high places, then dress down with the thick, smooth, flat file and try again.

When Filing Is Necessary, it should be confined to one edge in order that at least one good edge is retained, for it is almost impossible to secure as regular a surface with a file as that made by a grinding machine.

An Example of Ill-Fitting Rings Is Shown at B, Fig. 2B, and at the left in Fig 2C the space C shows that the ring was sprung in putting it on the piston.

A Very Simple and Effective Means of Holding a Ring for Fitting Is Shown In Fig. 1. The ring is placed on a block of wood and a few small nails driven into the block both inside and outside of the ring in such a manner that the ring is held securely in place for filing. The heads of the nails are then cut off, the ring removed, and the nails filed down so that they will extend just below the top surface of the ring when it is replaced on the block. With the nails well placed, there will be no danger whatever of breaking the ring when filing.

Having Fitted One Ring, put it in place immediately and repeat the operations with the next ring.

A Quick and Safe Method of Slipping Rings Into Their Grooves is shown in Fig. 4. Take three strips of sheet metal, brass or tin, for instance, about 1-32 in thick, ½ inch wide and 5 inches long; bend these at right angles and hang them on the edge of the piston at equal distances apart. The ring may then be slipped over these till it is opposite its groove, when the strips may be removed and the ring allowed to slide into place. The same strips may also be successfully used in removing the rings.

Emery Cloth Should Not Be Used In This Work, as cast iron is very porous. Grains of emery which will remain in the pores, work out later and cause much damage.

HINTS ON FITTING RINGS AND REPLACING CYLINDERS.

When Fitting a New Ring Into an Engine, the ends—or landings, to be technical—should be left so that the edges overlap slightly when the ring is in the cylinder as shown at Fig. 5.

Then Make a Plug of Yellow Pine (Fig. 8) an easy fit in the cylinder and square one end. Lay the ring on this end with a small batten across secured by a screw through the center, but not holding the ring tightly. Smear the bore as evenly as possible with a little vermilion and lubricating oil mixed to a paste, and move the ring to and fro in the cylinder while held square by the plug. Generally, it will be found to bear hardest at each side of the slot. File such places carefully with a 6-inch smooth file, try in again and continue.

When the Ring Fits Fairly Well All Around, the overlap of the ends should be absorbed; if not, file them until the edges have about 1-64 clearance when the ring is in the cylinder.

If the Ends of the Rings Be Hard Butted Against One Another when in place in the cylinder they may be buckled by expansion when hot, and make starting a two-man job.

REPLACING PISTON IN CYLINDER.

When Replacing Piston in cylinders of gasoline engines, some device must be provided for holding each ring in its groove so it will easily enter the bore.

Copper Wire May Be Used to Advantage where one or two pistons of the same size are to be replaced. In repairing engines of various sizes and replacing their pistons, the tool shown in the sketch, Fig. 10, can be quickly applied to each ring just before it enters the bore.

The Tool Is Made from a length of bicycle chain with a lever attached to one end on which a hook is fastened in such a manner as to take up the chain and close it in on the ring.

PUTTING CYLINDERS ON PISTONS.

Another Method: It is not difficult to put a single cylinder back on its piston after it has been necessary to take it out, but it is not so easy when the cylinders are cast in pairs, it is difficult to "dodge" the rings into the cylinder barrels simultaneously. The job is greatly simplified by taking the precaution to place the cranks up and down, so that one piston is at its highest point and the other is at its lowest. This means that the pair of cylinders can be dropped straight over the pistons, the rings of the upper piston being guided into the cylinder before those of the lower piston are replaced. When it comes to dropping one of the mono-block castings of four cylinders on to four pistons it is still best to work this way, so that only one other pair of hands are required and that the two upper pistons may be guided into their cylinders first and then the two lower.

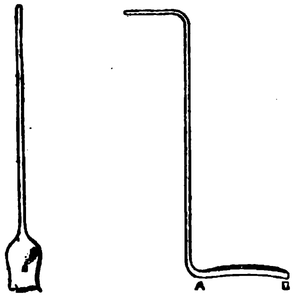


Fig. 1 Fig. 2
Carbon Scraping Tools

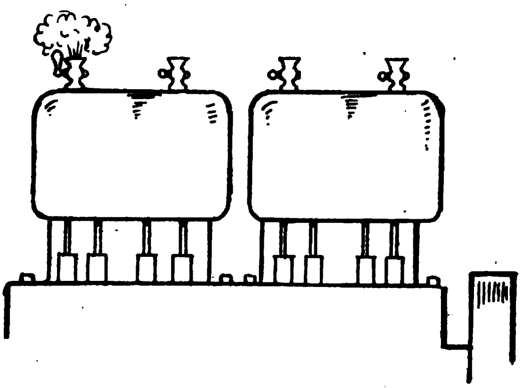


Fig. 4—Testing for a Missing Spark Plug Through Compression Cocks. Formation of soot short circuits the plugs and keeps them from sparking at the points.

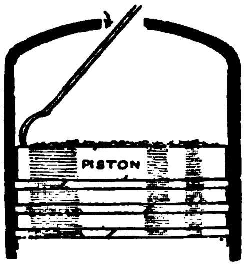


Fig. 3—Scraping Carbon from End of Piston

CARBON DEPOSIT.

This is one of the most common troubles of an engine.

If a poor grade of oil is used or too much oil or too rich a gasoline mixture in the carburetor, this will turn to soot or carbon and will deposit in the combustion chamber and on the end of the piston, and will also get under the valves and cause them to leak and will also fill in the hollow space in the spark plug and short circuit it.

Effect: of this deposit is noticeable in that it will fill up the space between end of piston and head of cylinder and thereby increase the compression and cause pounding.

This formation of carbon sometimes hardens and becomes red hot and will fire the charge of gas pre-maturely. In fact, it will cause endless sources of trouble, the most common trouble being the fouling of the spark plug.

MECHANICAL METHOD OF CLEANING CARBON.

A mechanical method for cleaning this carbon is to dismantle the engine, taking off the cylinders and scraping the carbon, but inasmuch as this will require a day or two of time it will be possible, in some instances, to make scraping tools as shown in Fig. 1 and 2 and use them as shown in Fig. 3, passing the tool through the spark plug hole.

To Make These Tools; obtain a length of iron rod, 10 in. long and about ¼ in. thick. Heat one end in the fire till it is red-hot, and then, with a heavy hammer and an anvil or iron block, forge the same to the shape shown in Fig. 1. The end is then ground or filed away to give a cutting edge, as shown. From another piece of rod, of the same dimensions, cut off a 12-in. length, and by heating the same as before, bend the end into shape shown at Fig. 2. The dimensions, A to B, will be half the bore of the cylinders operated upon. The side of this is also ground away to form a cutting angle, as shown. The other end is then bent at right angles to form a handle.

Our tools are now complete and ready for use.

Remove the Sparking Plugs and Valve Caps, and also any water connections at the top of the cylinders that may interfere with the operation. (The removal of the front mudguards, if easily detachable, renders the engine much more accessible, besides preventing their use as a bench.)

Place the Piston to Be Worked On at the Bottom of the Compression Stroke (both valves being shut). Insert the first tool in the plug hole, as shown in Fig. 3, having previously wiped the edge of it with a greasy rag. The cylinder walls can be felt, and when the edge of the piston is felt, bear hard upon the tool and draw it slowly towards the center of the piston, then remove it and wipe off the deposit sticking to it; again wipe it with the rag, and repeat the process until the the whole of the surface of the piston has been covered. Through the valve port insert, at the end of a flexible wire, one of those tiny electric lamps sold for tiepins, etc., and worked from a small dry battery. By lighting the lamp and applying the eye to the plug aperture, the condition of the piston can be seen, and, if necessary, a second scraping can be given.

Bring the Piston Slowly Up to the Top of Its Stroke (the valves remaining shut), and insert tool No. 2. Let the cutting edge bear upon the cylinder head, and turn slowly round and round, until it is felt that all the deposit is removed. The same tool can then be used to remove the deposit from the valve pockets.

The Writer's Experience Goes to Show That It Is the Deposit Formed Upon the Piston That Matters Most, rather than that upon the cylinder head; still, both should be cleaned.

When the Combustion Head and Valve Pockets Have Been Cleaned, apply the mouth to the plug hole and blow hard; this will drive the remaining deposit into the port holes, when it can be removed with a rag.

The Four Cylinders Having Been Finished, the engine is started up and all the compression taps opened, when any deposit that remains will be blown out.

Again Remove the Sparking Plugs, and get an assistant to turn the starting handle quickly and insert about a pint of kerosene through each plug hole, stirring the same round with a suitable rod; this will wash down any deposit that may remain and free the rings.

The Oil in the Base Chamber Should Be Changed, as the kerosene will have thinned it. These operations sound, no doubt, somewhat lengthy on paper, but are quickly executed, and should not take more than half an hour, and the effect on the engine is just as if the cylinders had been removed and scraped.

As Before Stated, the operation is only applicable to engines where the plug holes are at the top cf the combustion chamber, but where they are at the side some modification of our first tool must be devised. The writer is aware that the whole job is unmechanical; still, it works in practice.

* HOW TO REMOVE CARBON DEPOSIT CHEMICALLY WITH KEROSENE.

In Using Kerosene as a Carbon Remover the Kerosene Is Introduced Into the Cylinder and the motor turned over several times by hand to get the oil thoroughly spread over the surfaces. The motor is then allowed to stand over night. In the morning the motor is started and run for a few minutes, or until the smoke has disappeared from the exhaust.

There Is Some Divergence of Opinion as to the Proper Amount of kerosene to be used. Some people think half a cupful is necessary, while others believe that a tablespoonful is enough.

The Best Way Seems to Be to Use the Lesser Amount at Short Intervals of, say, a week or two, depending on how much the car is being used. The oil should always be drained out of the crankcase and new oil put in the morning after the kerosene is employed.

HOW TO FIND WHICH SPARK PLUG IS MISSING.

An Easy Way to Test and Find Which Cylinder is missing is to open the pet cocks, one at a time. (Fig. 4.)

If a Flame Shoots Out, then that cylinder is firing O. K., if not then that cylinder is missing for some reason and most probably due to a sooty spark plug. Take the plug out and clean it.

CAUSE AND REMEDY OF A KNOCK.

If an Engine Knocks it may arise from several causes. A loose flywheel is about the worst cause. It is difficult to find if a flywheel is loose, and in some cases it is a serious and tedious job to dismount the engine. If the flywheel is suspected of being loose, the best way to ascertain this is to jam the engine, so that it will not move in either direction. This can be done by jamming the starting handle, so that the engine cannot turn backwards, and with a strong pair of gas tongs holding it tight in the other direction, while an assistant grasps the flywheels with both hands to see if it is loose. Or the end of a crankshaft can be bolted with two bolts and a plate to a stout piece of flat iron. The flywheel should be tapped with a hammer if it seems tight to the hands. If it is loose a new key must be fitted. This requires very considerable care, and should not be attempted by an amateur unless he has some very considerable mechanical skill.

If the Knock Is In the Flywheel, and does not proceed from overheating or premature sparking, it may be in the gudgeon pin. If the bush is worn, a new one must be turned up, and possibly a new pin fitted.

If the Knock Is in the Big End of the Connecting Rod, the brasses must be filed away till the shake is removed. Some crank pins in engines that have done a good deal of work will be found to be oval, owing to the pressure of the explosion being received on one side of the crank only. The crank should be carefully callipered all around to see if there is any part that has a less diameter, for if the big end were tightened on the small diameter it would bind hard when the crank had turned through a quarter of a revolution. The breakage of the connecting rod of a traction engine has more than once resulted from such a cause, but it is not likely to occur in a motor car engine, as the effort to turn the engine by hand would at once show that something was wrong. The engine, however, might run stiffly for some time.

If the Main Bearings Are Loose, the edges of the brasses must be filed up, and possibly a slice taken off the aluminum crank case. If new brasses are put in they will, of course, be thicker than the old ones, and if the aluminum crank case has been previously filed down a strip of asbestos millboard must be inserted to keep the joint tight, otherwise the oil would escape on the road.

HOW TO SCRAPE AND REFIT BEARINGS.

The Engine Must Be Dissembled. Take out the crank shaft and examine it first.

If Any Rings, or Ridges Can Be Seen, or Felt, the crank shaft should be held in the vice between grooved wood blocks, and carefully emery-clothed (Fig. 1). To do this properly, some fine emery cloth should be torn into strips about 1¼ inches wide and well oiled, and the cranks rubbed, as shown in the illustration. Emery tape is better for the work when obtainable. If the emery cloth completely encircles the shaft, and a long, steady movement be imparted to it, there will be no tendency to make the latter oval.

---

*A Carbon Chemical Remover Called "Carbon Chaser" made by the Whitney Co., of Cleveland, O., has been tried and tested, and found superior to kerosene.

The concern also makes, what is called "Inter Lube." This is a compound to be mixed with gasoline. The makers claim it will not only lubricate internally, but will prevent carbon deposit and smoke.

Bearings

The adjustment and replacement of bearings in an engine or some part of the transmission such as a gearbox, is a matter requiring a good deal of skill and experience to effect.

With the exception of the small end of the connecting rod (Fig. 1), all bearings are split lengthwise (Fig. 2). The small end of the connecting rod has a plain phosphor-bronze bush forced in fairly tight.

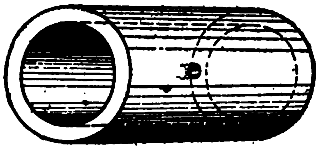


Fig. 1

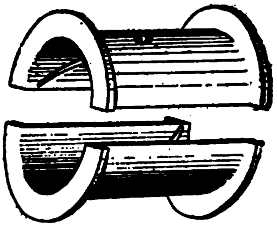


Fig. 2

When worn, a new bush is fitted which is turned and bored to a free fit without any trace of rocking or end movement.

The split brasses in time wear oval, mainly on the lower half.

If the wear is slight, careful filing of the faces, so as to close up the bearing a slight amount, may suffice to effect adjustment.

In some cases a slip of metal is inserted between the brasses, which piece can be filed down for adjustment.

If the wear is considerable, in addition to drawing the halves together, the surfaces will have to be "scraped" true with special scraping tools till an even fit is obtained all over between the shaft and brass.

The uneven parts are located by smearing the surface lightly with a mixture of red lead and oil and noting how it distributes on the surface after the shaft and bearing are in place.

Many bearings are "lined" or metalled with "babbet" metal or anti-friction alloy.

When worn, the bearing halves are bored out true and relined.

The surface is tinned and the molten metal run in either solid to fill up the bore completely or around a mandril smaller than the shaft.

A true bore to fit the shaft is then made in the lathe and the bearing cut through, after which the necessary oil channels are cut in the surfaces.

When a bearing is adjusted it must also occupy the same relative position as before in its bed, and to effect this, packing the lower half with very thin sheet phosphor-bronze or foil may be necessary.

Various thicknesses from 1-1000th inch can be got suitable for this purpose.

A good practice is to slightly "ease off" the bearing at the dividing line, to avoid any risk of binding.

It is of great importance to the running of a bearing that the shaft be dead true and cylindrical and the surface quite smooth.

Any ridges or rough places should be removed in the lathe before attempting to adjust the bearing.

When fitting a plain bush very moderate pressure should suffice to drive it in place.

A tight fit may cause the bush to contract, necessitating reamering out to make it fit.

A bush that is an easy fit requires pinning to prevent it turning round. Particular care should be given to cutting oil channels and to note in the case of plain bushes that the oil holes are drilled right through.

The removal of a worn bush is best effected by careful forcing from one end in the vise over a collar or large nut.

Another plan is to force it out by a screw bolt passed through the nut, exerting pressure on a collar whilst the head pulls against the end of the bush.

Hardened steel bushes can be used, providing the shaft is case-hardened to resist wear.

The bushes require grinding after hardening, and the running clearance should be a shade more than for phosphor-bronze. Ample oilways should be cut in the surface.

Different size of bronze bushings should be kept in stock by all repairmen for making bearings.

They can be obtained of almost any brass foundry, but be sure and tell them you want only good bronze for bearings.

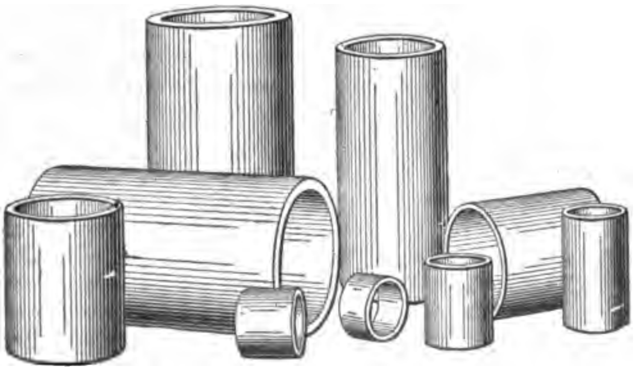


Fig. 2—Bronze Bushings Needed in Every Repair Shop

It May Be Found That a Crank Pin Is Not Only Scored, But on Testing With Callipers, Is Found Out of Truth, i. e., not perfectly circular.

The Usual and Best Plan is to have the shaft ground true on a special grinding lathe, but this may not always be possible owing to lack of facilities.

The Best alternative is to, first of all file up (with a very smooth file) the untrue part of the shaft to as accurate a circular shape as possible, testing frequently with callipers.

A Lead "Lap" Is Then Made In Clamps as Shown in the Sketch Fig. 4. This is bored out to a size, and paper or card packing inserted between the two halves so that the halves can be gradually closed down by the bolts onto the crank shaft. The lap is dressed with flour emery and oil and worked round the crank pin by hand till a good surface is obtained.

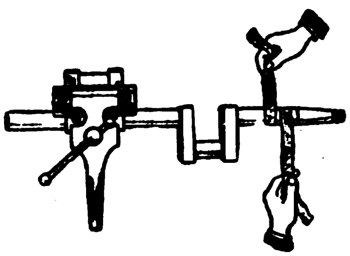


Fig. 1—Emery Cloth Being Used on a Crankshaft

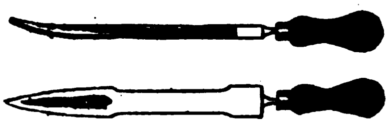


Fig. 2—Scraping Tools

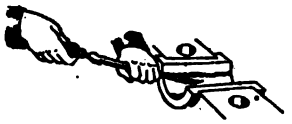


Fig. 3—Using a Scraping Tool On a Bearing Surface

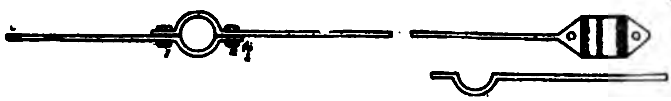
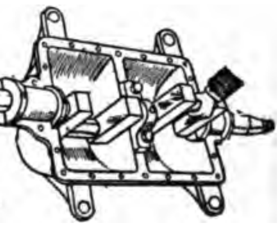


Fig. 4—A Grinding Tool or "Lap" for Trueing up a Worn Shaft When Proper Grinding Machine is Not Available



Testing Crankshaft Bearings After Treatment With Scraping Tools

Having Satisfactorily Done This, the Ridges In the Main Bearings Should Be Carefully Scraped Away. The scraping tools (see Fig. 2 and 3) are made from worn-out half-round files which are carefully ground upon a grindstone.

Then the Crank Shaft Should Be Placed In Position on the Lower Half of the Crank Case and the bearings bolted into position. It will then probably be found that there is some slackness, and if such is the case the faces of the two halves of the bearings should be lightly draw-filed until the shaft is a better fit. Next the top halves and crank shaft should be removed and the surfaces of the bearings smeared with a thin mixture of red lead and oil. Replace the crank shaft and tighten the bearings down. Then give a few turns by hand.

Again Remove the Crank Shaft. The parts of the bearings showing bright should be carefully scraped. This process should be repeated until the surfaces of all the bearings are smooth and level.

Before Finishing, it should be carefully noted that the oil channels are of sufficient depth.

Scraping Is Not Easy Work, and Requires a Fair Amount of Skill, so it is advisable first to practice on an old bearing. When the main bearings are completed, the connecting rod big-end bearing should be treated in the same manner. Also the cam shaft bearings should be scraped if they need it. When at work on the bearings, it should be remembered that metal once taken away cannot be replaced unless new parts are fitted, so extreme care should be taken.

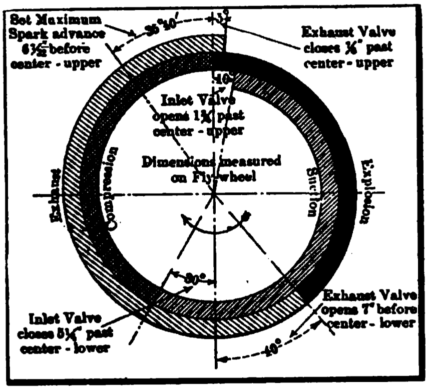
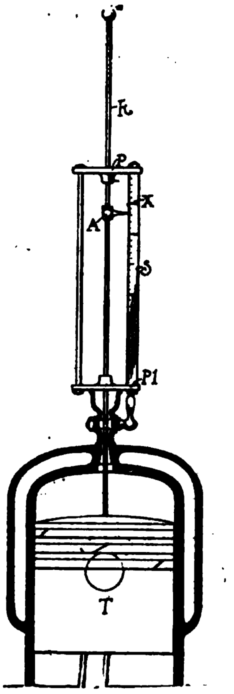

Set Maximum Spark advance 6 3/32" before center - upper
35°30'
3½°
Exhaust Valve closes ⅛" past center - upper
10°
Inlet Valve opens 1⅛" past center - upper
Dimensions measured on Fly-wheel
Exhaust
Compression
Suction
Explosion
30°
Exhaust Valve opens 7" before center - lower
Inlet Valve closes 5⅛" past center - lower
40°

Fig. 1—Table of Valve Settings

Half the Motors Running Are Out of Time—The reason for desiring to accurately time the motor is based upon the necessity of igniting the mixture between the interval of inspiration and the interval represented by the power stroke. The mixture should never be permitted to burn during the power stroke. This stroke should be devoted to expansion work. On the other hand. the ignition should not take place before the completion of the suction stroke. In poorly timed motors the gas being taken in is reduced below the best level and the work that the compressed mixture is capable of doing falls below par because the burning of the gas is prolonged into the power stroke. In dealing with this problem there are four prime considerations: (a) The carburetor must supply a well-balanced mixture; (b) the intake valve must be timed to admit the fullest measure of mixture; (c) the ignition must be energetic and precisely timed so that the gas will be ignited and burned before the beginning of the power stroke; (d) the exhaust valve must be opened at the instant it will permit of the scavenging of the cylinders during the remaining stroke, thus paving the way for the beginning of the succeeding cycle under the most favorable conditions. In dealing briefly with this problem it will suffice to state that the timing of a motor must be varied to suit its characteristic and the speeds of its range of perfomance. Fig. 1 is designed to tell the reader how timing of the valves and the spark is reckoned, and one type of timing is given in this diagram the conditions being such that a motor so timed will be a good average performer. This will be true if the motor is of medium size and operates between 800 and 1,500 revolutions per minute. As a further aid to those who are in quest of exacting results, a table of valve settings is here reproduced.



PISTON STROKE INDICATOR.

In Fig. 2 is shown rather a handy and ingenious device for setting camshaft and ignition gears and timing other features of amotor relative to the position of the piston in the cylinder.

The frame is made entirely of brass except a steel rule or scale which forms a standard on one side.

This frame when in use rests upon the top of a priming cock as illustrated and serves as a guide for the steel rod R which is free to slide up and down.

Between the plates P and P1 of the frame a little adjustable indicator arm A is attached to the rod R in such a position that its point registers with the markings on the scale S.

When this little instrument is used in timing ignition the scale is hardly required except to show when the piston starts to descend.

For instance, suppose that in setting the spark so that with the spark control lever fully retarded the spark will occur just as the piston starts to descend on the explosion stroke.

We have placed the instrument in position on the cylinder and turn the motor over until the intake valve begins to open.

It will be noticed that as the intake valve opens or immediately after it has opened the rod R will descend with the piston.

The operator is now aware that gas is being drawn into the cylinder and as the bottom center is passed and the rod begins to ascend slowly the piston T is on its compression stroke.

Close observation of the indicator arm as the motor continues to revolve slowly, now shows that it rises to the point X of the scale, rests there for a second and then starts to descend again.

The operator is now aware that the piston is on its explosion stroke and backs the motor up until the indicator arm returns almost to the point X on the scale and sets his ignition device so that the spark occurs at this point.

In setting timing gears an instrument of this kind is more important.

The valves of every motor are set so that they will open when the piston is at a certain distance from the top or bottom center of a certain stroke.

Therefore when the instruction book of a car states that the inlet valve opens 3-64 inch late on top center of the piston stroke it means that the valve should start to open when the piston has descended 3-64 inch from the top center on the intake stroke and when it says that the exhaust valve opens 15-16 inch early on the bottom center of the piston stroke it is meant that the exhaust valve should begin to open 15-16 inch before the piston reaches its bottom center on its explosion stroke, etc.

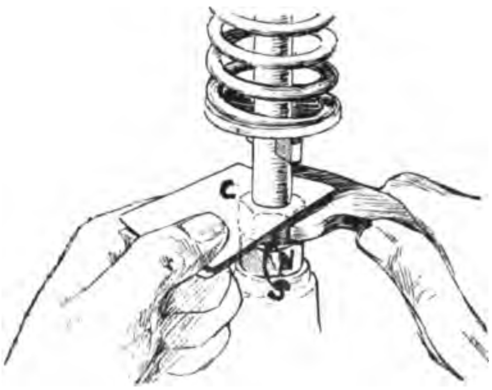


Fig. 1—Inserting a Card for Adjustment

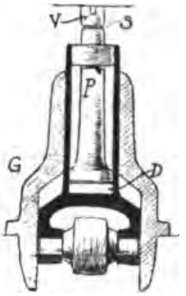


Fig. 2—V, Valve. S, Space Between Valve and Plunger. P, Plunger Rod.

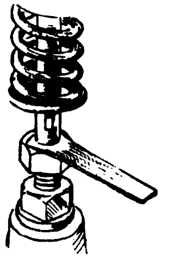


Fig. 3—Tool Inserted between Valve and Plunger.

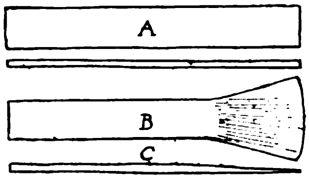


Fig. 4—Tools for Binding a Noisy Valve

Difficulty is frequently experienced in locating noises in and about the power plant, probably because there are so many of them that it is difficult in determining where to begin.

The best way, perhaps, is to go about it in a systematic manner, starting with the most likely sources, as in the valve lifts, since in them the cause of the noise is of a mysterious nature. Referring to the accompanying figure.

ADJUSTING THE VALVE TAPPETS.

Proper adjustment of the valve tappets will help in reducing the noise which invariably occurs when there is any wear.

The proper space between the ends of the push rods and valve stems is about 1-64 and 1-32 inch.

The smaller the space, less noise; but sufficient space must be allowed due expansion when the engine is warm and irregularities in shape of cam or roller.

Sometimes one or two tappets may need adjustment, while others may be in good shape; in such cases there will be a clicking sound at regular intervals.

HOW TO FIND A NOISY VALVE.

The noisy one can be located with a simple tool, B and C, Fig. 4. The tool is made of a strip of brass 1-16 thick by 8 inches long, with one end tapered. Place to 1 under a suspected valve stem, as shown in Fig 3, and when the noisy one is found the insertion of the tool will cause the clicking to cease abruptly and will remain quiet until tool is removed.

The experienced repairman can generally find a tappet that is badly out of adjustment in a very short time by simply working the tappets of each cylinder up against the valve stems and down again, with his fingers, while the pistons of the respective cylinder are on their compression strokes.

VALVE ADJUSTMENT.

If all the valve stem spacing of a motor are to be examined and adjusted, perhaps the best method to follow is to turn the motor over by hand until the piston in the first cylinder is about half-way up on its compression stroke, at which time both valves of that cylinder should be tightly closed; then examine the space between the stems and push rods.

PROPER ADJUSTMENT.

In the absence of a suitable steel gauge for regulating valve space, many repairmen use a common business card, as shown in Fig. 1. The card C is folded once and slipped between the ends of the stem and tappet, the lock nut N is loosened, and the stud S is screwed up or outward until it just begins to pinch the card and prevents it from sliding about as readily as first. The card is then removed and the lock nut tightened.

When both the inlet and exhaust valves have been adjusted in this manner, each one should be individually tested with a single thickness of the card to see if the valves remain tightly closed throughout their required period. This is best done by sliding the single thickness of card gauge back and forth as the motor is being turned slowly from the closing to the opening points of each valve. The marks on the flywheel may be used to advantage in this operation if accessible, but they are not necessary. One can slide the card under a stem and turn the motor over until the car is seized, indicating valve opening, then a little farther until it is free again, which marks the closing of the valve; now, by turning still farther and continually sliding the card about, if the card is not seized before the regular time for the valve to open, according to either the position of the piston or crank-handle, the adjustment is about right, and if the card is prematurely seized the space is insufficient. The valve in each cylinder should be adjusted in the same manner.

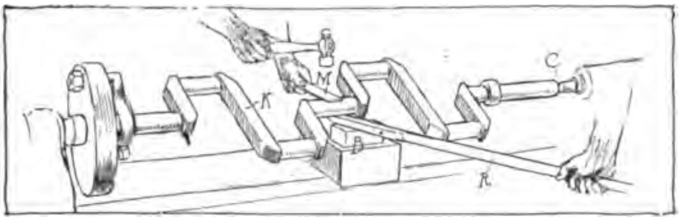


Fig: 1—Showing Method of Straightening a Bent Crankshaft

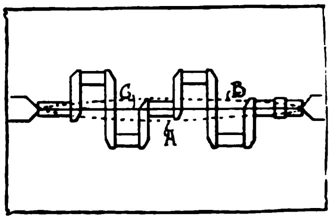


Fig. 2- Details of the Operation

In Fig. 1, One Method of Straightening a Slightly Bent Crankshaft Is Shown. This shaft is bent as indicated by the dotted line, A, Fig. 2, only to a very much less extent, the bend not being visible to the naked eye except when the shaft is revolving in a lathe with a tool or other object held stationary, close to the center bearing surface.

In Testing for a Bent Crankshaft, one should not be misled by a bearing surface of the shaft that is probably worn out of rouhd, the test should be made at the side of the bearing where little or no wear is liable to take place.

There Are Few Repairmen Who Will Undertake to Straighten a Bent Crankshaft, and by many it is claimed to be impossible to make a lasting repair to a shaft which is out of true. However, as the repairman is occasionally called upon to fix-'t-up, the means generally employed is shown herein.

As in Fig. 1, the Shaft K Is Fixed Between the Centers C of a lathe, a block or blocks B, are placed upon the lathe-bed for a fulcrum, and a bar of iron R, or preferably of wood, is used as a lever. If an iron bar is employed a piece of brass, wood or lead should be placed between it and the bearing surface of the shaft for protection.

Assuming That the Shaft Is Bent as Indicated by the Dotted Line A, Fig. 2, it is pried up with the bar R, till it assumes the position indicated by the dotted line B, and while held in this position an assistant holding a piece of brass M, on the bearing surface with one hand, and with a hammer in the other, strikes the shaft a sharp light blow.

The bar and blocks are then removed, the lathe started, and the shaft tested again for results. This treatment is repeated again and again until the shaft is straight as indicated by the line C. It is generally a long and tedious job, depending greatly upon chance and the ability of the operator of the bar to guess the proper amount of pressure to apply and the proper place to apply it.—Motor Age.

FINDING LOOSE BEARINGS IN AUTOMOBILE ENGINES.

The Usual Method of Finding a "Play" in Connecting Rod Bearings on automobile engines is to remove the lower half of the crank case, open the cylinder relief cocks and "feel" the connecting rods either by hand or pry-bar. Often the play is so small that the hands fail to locate it, in which case the pry-bar is used. Very often no leverage can be had on the pry-bar, then this method is not positive.

When There Is Any Uncertainty About the Pound or Looseness of a Rod or Main Bearing, a heavy pry-bar with exceptionally good leverage must be used to "feel" the crankshalf in its bearings. It is very inconvenient, however, to work such a bar up and down beneath a car.

The Best Method I Have Found is shown in the sketch. Run the car over a pit, if possible, although the bare floor will do.

Raise the Car by Means of a Jack to Suit the Conditions for Testing.. If the rod bearings are to be tried, run a jack head against the lower half of the connecting-rod bearing and work the jack handle up and down. The smallest amount of play can be detected in this way, especially on the main bearings, where the pressure of the jack is applied on the crankshaft against the weight of the car and "play."

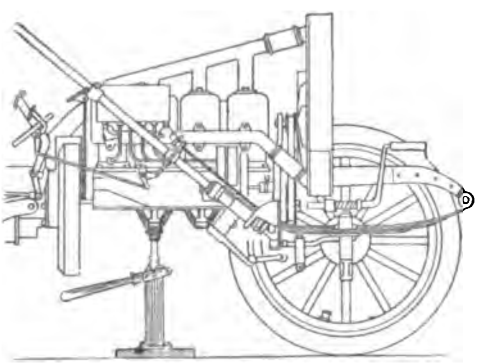


Fig. 1—Finding Loose Bearings with a Jack

TIMING VALVES

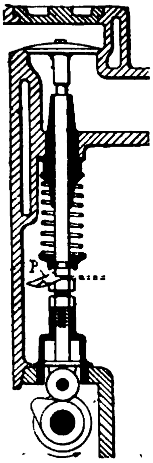


Fig 7

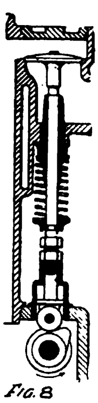


Fig. 8

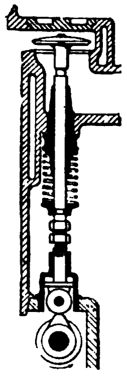


Fig. 9

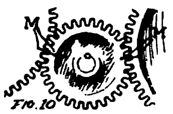


Fig. 10
MARKS ON TIMING GEARS

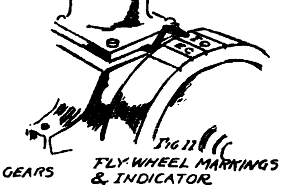
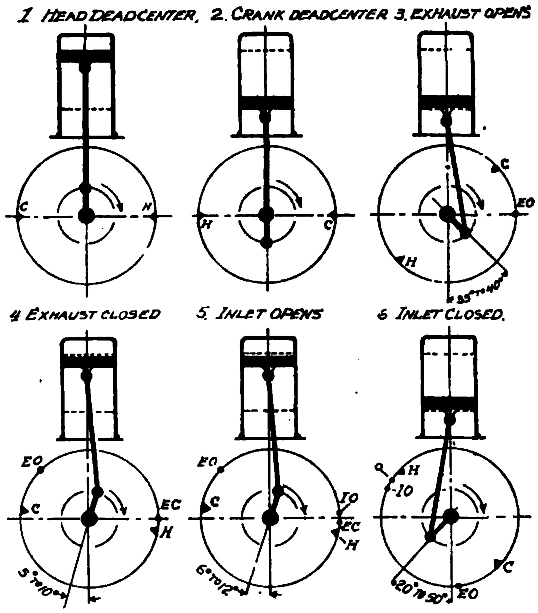


Fig 11
FLY-WHEEL MARKINGS & INDICATOR.



When Timing the Valves of a Motor, the Valves Must Open and Close Precisely at the Proper Moment, otherwise uneven working and waste power are inevitable.

The Points of Opening and Closing of Valves are Designated in Two Ways, either in terms of degree around the flywheel, or as distance moved by the piston in the cylinder.

As It Is Much Easier, After the Motor Has Been Assembled, to Determine the Position of the Piston from Marks on the Flywheel, this method has been universally adopted. In the factory, as soon as the engine is finished, two marks, diametrically opposite are located on the rim of the flywheel, such that when one is directly over the center of the mainshaft the piston will be at the end of one of its strokes, or in other words, when either of these marks is on top the piston will be on one of its dead centers.

Referring to Valve-Timing Diagram, Figs. 1 to 6, showing the timing of valves for a one-cylinder engine, it will be noted that when the Mark H. passes a vertical line drawn through the center of the shaft, the piston has just reached the outer end of its stroke, and when the mark C comes into this position then the opposite condition is true. These points are respectively known as the head and crank end dead centers.

Experiments Have Shown That the Exhaust Valve Should Open About 35 or 40 Degrees Before the Crank arrives at the Crank-End Dead Center; therefore, Fig. 3 shows, approximately, the relative positions of the crank and piston when this opening should occur.

In order to mark this position a line is drawn across the face of the flywheel at the point EO. Next, as the closing should take place from 5 to 10 degrees late, that is, after passing the head-end dead center, the point EC, Fig. 4, is located, as represented in the sketch.

The inlet, of course, open immediately after the exhaust closes, so that the point IO is next marked off a short distance back of EO.

Lastly, the time of closing the inlet is determined; this varies from 20 to 50 degrees after the crank has passed the crank-end dead center, and the point IC is settled upon.

Thus, Every Motor, on Leaving the Factory, Has All Points of Opening and Closing of Its Valves Correctly Marked Upon the Face of the Flywheel, so that when the engine is dissembled for repairs there should be no trouble in checking up the timing to see if the cam shaft gear is properly meshed; or, if it is suspected that the valve mechanisms are worn to such an extent that the efficiency of the motor is reduced, one has but to check the opening and closing of the valves with the marks.

As Each Design of Motor Requires a Slightly Different Valve Timing, it is impossible to give definite information that will cover all motors; but as most manufacturers furnish instruction books giving detailed timing of their product one should have no trouble on this account.

As the marks are scratched upon the face of the flywheel in the factory, these marks, as in Fig. 11, are generally lettered in the following manner to facilitate retiming or inspection: EO exhaust opens, EC exhaust closes, IO intake opens, IC intake closes, and in multiple cylinder engines figures denoting the cylinder numbers are also present.

When the valves have been properly timed, the timing gears are also marked as shown at M in Fig. 10, so that there should be no difficulty in replacing the cam shaft correctly.

In Figs. 7, 8 and 9, the Successive Positions of a Valve-Lifting Cam Are Illustrated; Fig. 7 shows the cam just about to raise the plunger which operates the valve; Fig. 9 shows the valve at its highest point, or maximum lift, and Fig. 8, the position of the cam and plunger after the valve closes.

You Will Notice That a Small Amount of Clearance Is Left as Indicated by the Dotted Line, in order to Insure a Proper seating of the Valve when the cam has left the roller.

Now, Let Us Assume That You Have a Motor, the Timing of Which Is Suspected of being Out of Order, it is a single-cylinder horizontal type such as shown in diagram Fig. 1, it does not give the power it did originally notwithstanding that fact that ignition and carburetion are good and the compression, though not what it should be, is not affected by leaky valves or ill-fitting piston or rings.

To Inspect the Timing, first turn the flywheel over with the starting crank until the point EO, Fig. 3, is directly over the center of the crankshaft, having first slipped a very thin slip of paper between the ends of the valve stem and the push rod as shown at P, Fig. 9.

The exhaust valve should now be on the point of opening, and by sliding the paper about while the flywheel is slowly being turned in the direction of its rotation, as soon as it is seized we know that the valve has started to open; and if this seizing takes place at or within an inch before or a trifle behind the mark EO, the timing is quite correct. Wear in the teeth of the timing gears, cams, the plunger-rollers and pins, and too much space between the end of the plunger or push rod and the end of the valve stem might, in the aggregate, cause the valve to close a couple of inches late according to the marks on the flywheel. The remedy for excessive wear in these parts is the fitting of new timing gears, new cams, rollers and pins, and the adjustment of the plungers, if adjustable, or peening out of the valve stems if not adjustable so as to reduce the space between the ends of the valve stem and push rods. The inlet valve should be inspected in the same manner except that its respective marks be employed.

In Timing the Valves of Motors Having More Than One Cylinder, this process, of course, must be repeated for each cylinder. As it is occasionally necessary to inspect the valve timing of a motor while installed in the chassis in such a manner that the marks on the flywheel are inaccessible, it is often possible to do so very readily by following the movement of the piston as shown in Fig. 13.

The repairman often has an instrument for this purpose such as is shown at A, but the amateur can get along very well with a plain piece of stiff wire or bicycle spoke upon which the top and bottom dead centers may be scratched as at TC and BC respectively. The wire is placed through the priming cock and allowed to rest upon the top of the piston, the motor is then turned over until the piston reaches either the lower or upper extremity of its stroke, and a thin flat file or a hacksaw blade or the like is used to scratch a mark upon it just opposite the upper edge of the priming cock.

When both dead centers have been marked off on the wire, one is ready to proceed with the timing.

The instruction book will state that the exhaust valve should close a certain number of degrees, or, say ⅛ inch late. The degrees relate to the distance traveled by the flywheel, or crank shaft to which it is attached, and the fractions of an inch relate to piston travel.

Thus Having Found the Top and Bottom dead centers, and with a very thin piece of tissue paper between the ends of the valve-stem and lifters, to learn or check up the correctness of the exhaust valve, turn the motor over until the piston reaches the top dead center of the exhaust stroke, then a little more until it has proceeded ⅛ inch down on the intake stroke, here the paper between the valve stem and the lifter should become free. A sixteenth of an inch difference in the movement of the piston is a very reasonable limit of accuracy. These methods may be used for all valves on all motors regardless of number of cylinders. [Motor Age.]

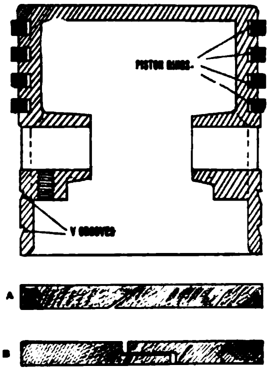


Fig. 5 Showing V Grooves in Cylinder

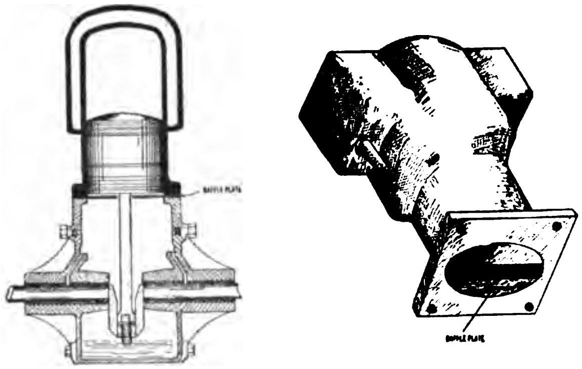


Fig. 6—Showing How a Baffle Plate Can Be Fitted in Lower End of Cylinder to prevent an excessive amount of oil getting in the combustion chamber.

ONE CAUSE OF SMOKE.

If the Vapor Is Black and Foul Smelling it is caused by too rich a mixture, this can be remedied in carburetor.

If the Smoke Is White or Blue, the engine is supplied with an excess of oil.

If Smoke Is Gray, there is too much fuel as well as a surplus of oil.

The Reason a Motor Excessively Supplied With Oil Smokes is that if there is too much in the crank case the entire lower portion of connecting rod will dip into it and the lubricant will be forced into the cylinder to work by the rings on the piston then into the combustion chamber.

THE REMEDY.

One Way Is to Cut Grooves in the Piston as shown in Fig. 5, these having a right-angled edge at the top side and sloped toward the base, so as to scrape the oil from the walls on the down stroke.

Another Method Is by Use of a Baffle Plate as shown in Fig. 6. This is a simple plate of sheet metal in which a slot is cut, through which the connecting rod works.

The method of installation is simple, the plate being cut to conform to the flange at the bottom of the cylinder and placed between it and the engine case, thus preventing an excess amount of oil finding its way into the mouth of the cylinder. Baffle plates of this nature are used in many motors, but this information applies to those without.

NOTES ON WIRING A CAR PROPERLY.

To Make a Good Job of the Wiring requires intelligent consideration of the work on hand.

It Requires Planning out in such a way that the shortest possible length of wire can be used—the shorter the wires the less will be the loss of current.

It Must Be Fixed as far as possible away from the adverse influences of undue heat, damp, grease and oil, and especially outside the range of possible mechanical damage or abrasion.

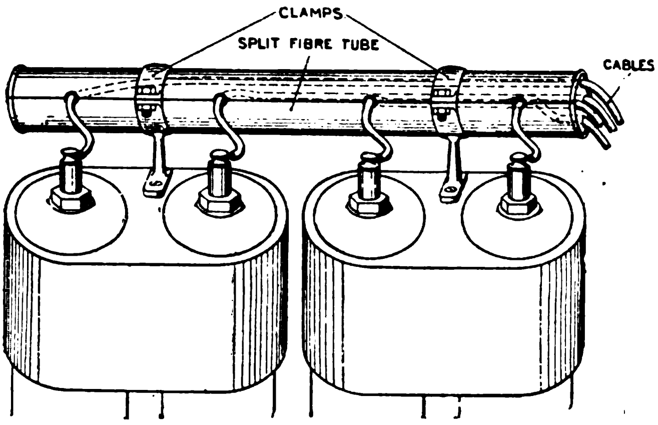


Fig. 1—Neat Method of Distributing the Cables to Sparking Plugs on Multi-Cylinder Engines. A divided fibre tube supported. on brackets encloses the cables and allows of easy inspection or renewal if required. Any number of leads or cables can be distributed. The eight plug leads required for dual ignition on a four-cylinder engine can be accommodated in a two-inch tube.

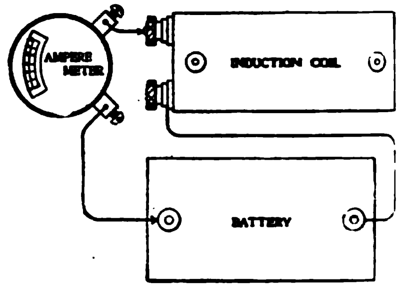


Fig. 2—Plan of Testing to See the Amount of Current Coil Consumes

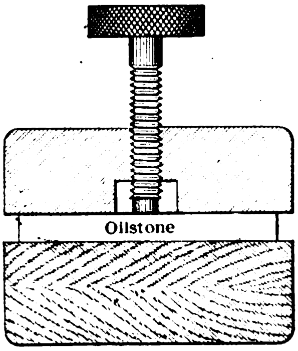


Fig. 3—Grinding Vibrator Screws Correctly

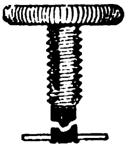


Fig. 4

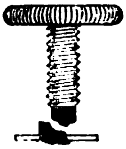


Fig. 5

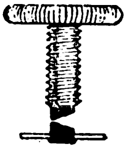
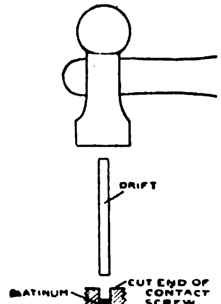


Fig. 6
Pitted and Worn Platinum Points Cause Sticking



Fg. 7—Re-fitting the Platinum Contact (It is best to buy these from maker of coil.)

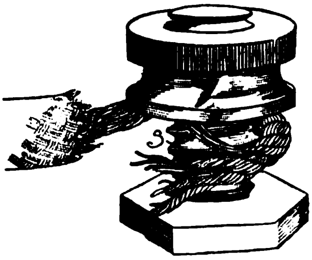


Fig. 8—Illustrating a Poor Connection which often causes a complete breakdown and hours of searching.

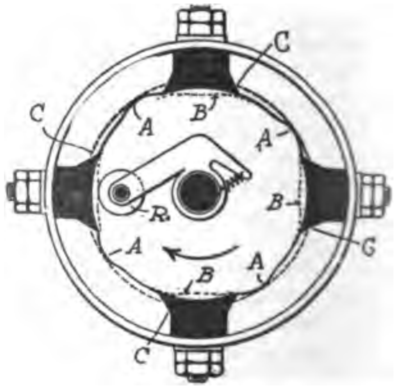


Fig. 9—Worn Segments on a Timer often causes missing explosions

CHART No. 164

As Good a Plan as Any is to run the wires in strips of tubing, which, with very little trouble, can be taken round corners and angles.

It Looks Neat, there is no strain on the wires, and in the event of it being necessary to examine the wires, the casing cover can be quickly unscrewed.

The Plan of Using Wires having different colors in insulation has much to recommend it, as mistakes in the connections thereby become very improbable. A letter can be scratched or stamped on near the terminals of contact maker, coil or distributor cover thus: B — blue, Y — yellow, and so on. Some motorists tie small labels or tags on the ends of the wires, or scratch a mark on the rubber insulation.

For Preference, some form of hook or slotted connection should be used to save time in disconnecting. as it only means slackening the nuts, whereas with the eyelet pattern one has to take the nuts and washers off, and they often get lost during the operation.

FITTING UP THE COIL.

A Coil Should Never Be Fixed to the Dashboard by means of metal lugs screwed to the coil box; unless this has been specially made with that object in view.

The Ordinary Rectangular Coil case is made of thin wood, rarely more than 5-16ths inch thick, and it is simply fatal to the coil to put screws into it.

An Instance Came to the Writer's Notice in which a coil so fitted gave rise to serious trouble. Two of the screws had gone through and pierced the condenser, and it was a long time before the owner of the car could make out why. he got such a wretched spark and feeble running of the engine.

He Put on a New Coil Temporarily, and then sent the other to be examined, and repaired, when cause of the trouble was located.

Coil Boxes Are Usually Provided With Metal Lugs on the side of the coil box for fastening to the dash.

HIGH TENSION CABLE CONNECTIONS TO THE SPARK PLUG.

The High Tension Wires Must always be well protected and no matter how well insulated the cables may be don't permit them to lay on the engine or any metal part.

A Good Substantial Method for keeping the plug wires free from the engine is shown in Fig. 1, Chart 164.

ADJUSTING VIBRATORS BY THE AID OF AN AMPERE METER.

The Usual Way of Setting a Coil Trembler is the rather rule-of-thumb- method of screwing down the trembler screw till there is a sharp musical "buzz' 'obtained, and, as near as it is possible to determine, to adjust the screws so as to obtain the same note from each trembler. (See Fig. 3, Chart 74.)

Current Consumption of the Coil Depends largely on how close the vibrator contacts are set.

Very Often It Happens that a good deal of current is wasted in having too close contact, and at the same time the platinums are soon pitted and worn out from the excessive sparking. (See Fig. 4, 5 and 6.)

There Is a Further Serious Disadvantage, insomuch that the firing point cannot be synchronised for each cylinder, the closely-set trembler firing the charge earlier than the lightly-set one, and thus it happens that an engine rarely gives off the full amount of power.

Perfect Synchronism is Required in obtaining full power.

This Explains Why Some Engines Often Give More Power on the magneto.

The Fault Lies in Bad Setting of the coil and sticking vibrators.

A Special Ammeter for Adjusting coils is a most useful accessory, as it is only necessary to connect it in the coil circuit, one terminal being joined direct to the positive or—terminal on the coil, and the other joining to the accumulator positive, the usual connection being temporarily taken off. (See Fig. 2, Chart 164.)

If the Coil Is Designed to Work With, for example, three-fourths or one ampere of current, each trembler can be adjusted till the needle of the ammeter registers exactly the required amount.

This Method of Setting Will at the Same Time Give an Indication of Any Defect in the Coil, contact maker, or wiring. Suppose, for example, one coil had a bad connection inside; the ammeter needle would jump about instead of remaining steady.

A Bad Contact Elsewhere Would Cause Probably a Very Low and Unsteady Reading, whilst a short circuit would send the needle far beyond its normal range, indicating the passing of an excessive current.

STICKING OF TREMBLER BLADES.

Sometimes the Blades or Vibrators Stick at the contact of the platinum points. (See Fig. 4, 5 and 6). Press down the trembler a few times. Crank engine slowly and see that all buzz.

To Test Spark Plugs—See Fig. 4, Chart 74—Start engine and then hold down each vibrator separtely and note if the engine lags or runs slower. If finally the engine does not run slower and it makes no difference by pressing that vibrator down, then the trouble is in that plug.

PLATINUM CONTACTS: HINTS ON ADJUSTMENT AND TRIMMING.

For Trimming the Surfaces of Magneto and Coil Platinums, suitable files are sold at accessory shops.

This Useful Tool is Known as a Contact File, and has a very thin, finely-cut blade.

In Addition to the File, get a small strip of wood about the width and thickness of one fold of an ordinary boxwood pocket rule.

It Must Be Flat and True. Cement or stick on this quite flat strip of No. 00 emery paper, and you have an excellent finishing-off tool for keeping the platinum points smooth.

If the Surfaces Are Merely Slightly Blackened it suffices to double a strip of the No. 00 emery paper and insert this between the two contacts, press them together, and pull the paper through them a few. times.

It May Have Been Noticed that the platinums have not worn equally.

One of Them "Pits," or has a depression eaten in it, whilst on the other a small blob or "nodule" forms.

It Is an Interesting Fact that this latter is the platinum from the other contact.

Every Time the Contact Separates a Minute Quantity of Platinum Is Transferred from one contact to the other. If the current is reversed by means of a reversing switch, the lost platinum will be transferred back to some extent.

In Fig. 4, Chart 164, This Pitting Is Visible, and this is the state a properly set contact finally arrives at. In Fig. 5 is the result of a badly-set contact, and which may result in a new trembler blade being necessary, because, being worn very unevenly, the platinum would have to be filed away right down to the steel, and the spark would quickly eat away the rivet hole and cause serious misfiring. The main requirements in trimming the contacts are to remove only as much of the valuable metal as is absolutely necessary.

The Surface Must Be Trimmed dead level and smooth, and in making the final adjustment of the screw, do not set the platinums closer than necessary to give a good steady buzz of the trembler.

Remember that a Light Contact on a Coil Trembler Means Economy of current. but if too light the engine will not run properly: above a certain speed it will be weak as the result of a feeble spark at the plug.

It Is Not Possible to state in exact terms what space there should be between the contacts when the armature is pressed down to its full extent, but a few trials will suffice to show the correct adjustment.

Magneto Platinums have as a rule to be set to give a very small break (½mm. or 1-50th inch).

The Surfaces Do Not Pit to such an extent as coil platinums, as the current automatically reverses at each revolution of the armature.

GRINDING A PLATINUM POINT.

To Grind a Platinum Point on the End of an Adjusting Screw of Vibrator Coil. Grinding a valve is quite a nice little trick, but to get an absolute even surface on an adjusting screw is something that cannot be accomplished with a file. Take 2 blocks of hardwood, as illustrated in Fig. 3, place a smooth oil stone between; after placing screws in position, as shown, move it back and forth or in a circular motion. The desired result will be obtained.

It is absolutely necessary that these points be flat and smooth, otherwise they will stick or burn together when working.

RE-FITTING A PLATINUM POINT.

A New Lease of Life Can be Given to a Vibrator Blade When the Platinum Contact Is Worn right down to the steel if it is knocked out from the other side, given a tap with a hammer, and then soldered on to the blade exactly over the hole.

The Tip Is to Use a piece of stout copper wire as a soldering bit, as only the smallest amount of solder must be used.

Very Few Motorists are aware that the usually discarded worn-out platinum-tipped screws contains quite a useful piece of valuable metal if it can be got out intact.

A Way of Doing It quite successfully is to saw off the end of the screw containing the platinum.

If the Cut Be Made about ¼in. from the end, the hole into which the platinum wire is driven is usually exposed, and then it is quite an easy matter to drive the bit of platinum out; the end of a steel knitting needle makes a useful drift for the purpose.

The Piece Thus Driven Out is often quite long enough to make a trembler contact either by riveting or soldering.

Of Course, if the saw cut does not reach the hole, it is a very simple matter to drill down.

The Method of Driving Out the Platinum is shown in the sketch ,Fig. 7, Chart 164, the end of the screw resting on a small nut or washer. A piece of sheet metal with a small hole drilled in it can be used instead.

FIRE CAUSED BY ELECTRIC IGNITION.

It Is Not Often That a Car Provided With Electric Ignition Takes Fire, and when it does, the accident may usually be traced to some carelessness on the part of the driver. Very often it is necessary to flood the carburetor to a certain extent, and then, when the engine commences to run, the driver often forgets to see that the needle valve is once more working properly. If the needle is stuck, then the spirit will commence to flow from the carburetor, and in some cases this leakage may amount to a positve jet. If this happens to come in contact with the overheated exhaust pipe or with any flame from an occasional misfire, the car may be alight in a moment. When the tank is on the dashboard the danger is further increased, although, with proper care, the dashboard position offers the advantage of a constant gravity flow to the carburetor, and dispenses with pressure-feed arrangements. The golden rule is to see that the needle of the carburetor is working after being depressed.

TROUBLESOME CONNECTIONS.

The Average Motorist Does Not Realize how much trouble and expense often can be saved by having the little apparently insignificant things about a car made as substantial as possible. The little things in mind are grease cups or oil caps that are lost and not replaced; loose nuts and bolts; acetylene gas piping that is loosely attached, too small in section, kinked, or so arranged with respect to the lamps that the hose-connections must be kinked or allowed to rub against some portion of the frame, causing rapid wear and leakage; and, perhaps, most important of all, shoddy terminal connections for the ignition or electric lighting outfits.

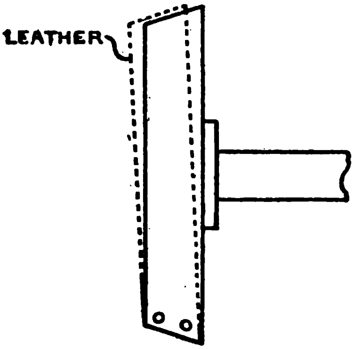
Dry battery terminal connections come in for no small amount of neglect and consequently are the cause of considerable trouble. Stranded wire connections without terminals are most undesirable. There are cases on record where many a joyful outing has been turned into a discouraging failure because of poor battery connections. (See Fig. 8, chart 164.)

COMMUTATOR CAUSES MISSING.

A Depression, A, Fig. 9, has been worn into the face of the fiber, on which the roller R of the revolving segment travels just in front of each stationary metal segment C. The result of this condition is that whenever high speed is attempted, the roller, on striking the further end of the depression, would tend to jump the greater part of the contact, as designated by the course of the dotted lines B, thereby causing a weak spark or no spark at all in the cylinder.

Generally When a Commutator Has Been In Service Long Enough to Become Worn As Described Above, the roller and pin of the revolving segment will also be found in bad shape.

To Repair a Timer in This Condition it is necessary to turn it down in the lathe, and a replacement is usually the most practical solution.



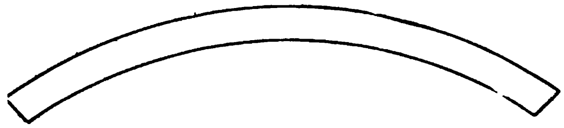


Fig. 1—Shape of Leather Strip for Covering Clutch Cone

Fig. 1—A METHOD OF FITTING ON NEW LEATHER TO CLUTCH CONE.

An alternative to leather for covering a clutch cone is "Raybestos" strip, used for brake lining, consisting of asbestos and brass wire interwoven. As this is made in parallel lengths, it is necessary to fit it on the cone in six or eight sections, the edges being cut at a slight angle, according to the diameter of the cone.

FITTING A NEW LEATHER TO A CLUTCH.

This is a class of renewal which is better, wherever possible, to put in the hands of an experienced repairer who has a lathe upon which he can true up the leather-covered cone after fitting.

A very fair job can, however, be made of the fitting of a clutch leather by the exercise of care and patience.

It does not always follow that a new leather requires fitting when a clutch is not giving satisfactory results.

Sometimes it will be found, on closely examining the old leather, that a shoulder from 1-16 in. to 3-32 in. deep has worn on it, and carefully trimming this off with a sharp file will give the leather a new lease of life, as it will enable the cone to go farther home and give a much closer contact between the surfaces.

If, at the same time, the whole surface of the leather be lightly scraped to remove any glaze, and two or three coats of castor oil or collan oil be given, results equal, if not better, to fitting a new leather will be obtained.

There is just one special detail to be noted, and that is to see that the copper rivets are well below the surface of the leather.

In a clutch that has had much use there is risk of the rivets coming flush, which causes a nasty gripping, or even difficulty in disengaging.

It is an easy matter to knock the rivets further in with a punch made of a piece of round steed about the diameter of the rivets.

When the fitting of a new leather becomes imperative, the clutch must be taken apart and the worn-out leather removed, cutting the underside of the rivets away with a small chisel and punching them through.

The old leather will serve as a templet or gauge as to shape for the new piece required, which must be considerably thicker and as uniform in surface as it is possible to obtain.

There are firms advertising clutch leather as a specialty, and they will supply a suitable class of leather, but any local saddler will cut a piece if any difficulty is experienced in getting it elsewhere.

If the leather is stiff, as it generally is, it SHOULD FIRSTLY BE GIVEN A DRESSING OR TWO OF OIL AND HUNG UP for a few days.

The key to success in fitting a new leather is to get it fixed quite tightly and true on the cone.

It requires, in fact, to be stretched over the cone.

One end of the strip should be cut square and secured by a rivet to the cone.

The other end then has to be brought round to meet it, taking particular care only to have it three-fourths on the surface of the cone.

This end can then be secured by a copper rivet; but it need not be cut as yet.

The remaining task is to force the leather right on the cone, drill the holes and countersink them and rivet up tightly.

There is an appreciable give in the leather, so that there will not be any great difficulty in forcing it right home.

The foregoing method will be found an improvement on marking off the holes from the old strip as, in this case, it is impossible to stretch the leather on the cone without drawing the holes out of register.

Some trimming up with a coarse file or rasp is almost sure to be necessary in lieu of being able to true up the surface in a lathe, but this will only be superficial; any high places will show up after running the clutch a short distance, and these can be smoothed down after.

In any case, it will be some little time before the new leather works down to a good surface. Whilst about the work, the importance of having the two members of the clutch lined up correctly should not be lost sight of.

The alignment may not be dead true on a car that has had a good deal of use, and the clutch could not possibly work well till it is readjusted.

A taper gauge cut from a slip of wood which can be inserted in different positions round the periphery of the clutch will show any serious deviation, in which event packing of the gearbox or adjustment of the engine bearings may be necessary; in either case this is work for an experienced hand to attend to.

MAKING GASKETS.

Perhaps one of the first lessons the young repairman is taught on entering a shop is that of making gaskets.

The Gaskets Between the Bases of the Cylinders and the crank case generally are made by stretching the drawing or wrapping paper, commonly used for this purpose, over the mouth or base of the cylinder, and then while holding the paper firmly in place with one hand the other operates a ballpin hammer as shown in Fig. 1, Chart 165. The round end of a light hammer should be employed in this operation, and the gasket is cut out by lightly tapping the sharp edges of the cylinder base through the paper.

This Method Often Is Erroneously Employed in making gaskets for aluminum parts; and as aluminum is very soft, the edge generally is broken down after the first gasket is made, the paper does not cut so rapidly, more hammering is required, the area of the contact surface is reduced and the joint is thus more difficult to render oil-tight.

To Make a Gasket for an Aluminum Case, the paper should be pressed over the bolt-holes and edges so that an impression is made that can be clearly seen; the gasket then can be readily cut out with a pair of scissors or a knife in much less time than it could be done with a hammer.

Lead, Copper and Asbestos Gaskets for Flange Connections of the Water and Gas Manifolds can be made easily with a peinning hammer as mentioned above, but rubber gaskets are more easily cut with a knife.

In Making Gaskets From Wire Asbestos Sheet Packing the hammer cannot be used to advantage, and it is advisable to cut out gaskets of this material with a pair of tin-snips, or an old pair of scissors.

In Some Engines the joint which secures the head to the cylinder forms also the joint for the circulating water. This joint requires great care in making.

The Car Owner Should Cut a Template of Tin or Zinc the Size Required (See Fig. 2), but the holes in the jointing material, through which the long studs pass, must be fractionally larger than the studs; for if there is not this clearance, and the jointing material has to be pushed on, most probably the edge will be pushed up alongside the stud; and when the head is put on, it will be turned back so that for a small distance round the stud there will be two thicknesses of jointing material, and then it will be impossible to get a tight joint.

The Writer Has Lately Used a Material Called Mobolene for joints. It appears to answer better than asbestos. The mobolene when cut out should be soaked with boiled oil, and left to dry for some hours before being used. If the jointing material when put in be smeared with black lead on one side, perferably the upper side, the head can be taken off without damaging the material. Two or three of these "joints" or "packings" should be carried in the car—not loose in the toolbox, but tied up between two pieces of stout cardboard.

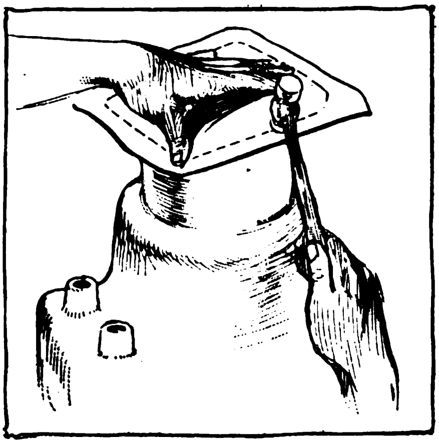


Fig. 1 - Making Gaskets

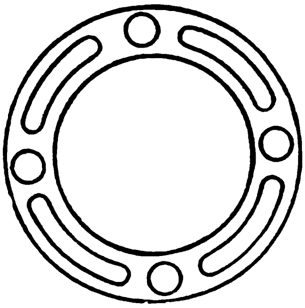


Fig. 2—A Copper Gasket lined with Asbestos. A good form of Gasket for Cylinders with Separate Heads

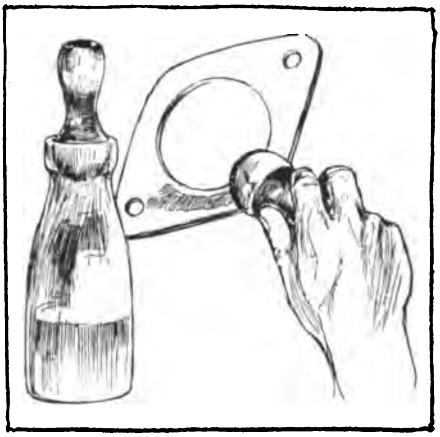


Fig. 3—How to Use Shellac on Gaskets

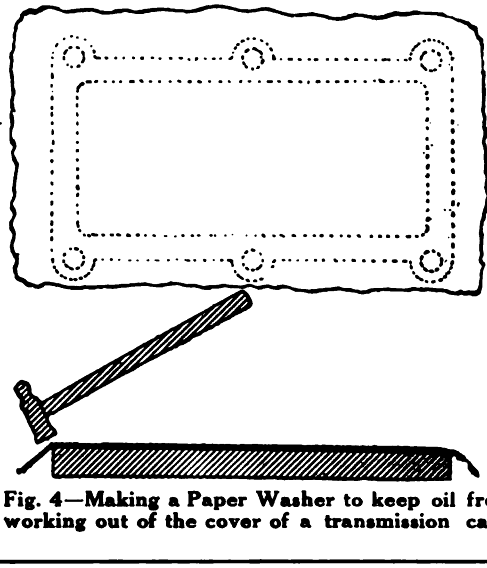


Fig. 4—Making a Paper Washer to keep oil from working out of the cover of a transmission case.

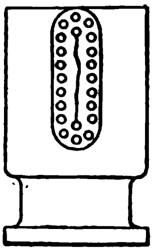


Fig. 5—Repairing a Cracked Cylinder

CHART No. 165

HINT ON HANDLING SHELLAC.

Every Motor Car Repairman is thoroughly familiar with the use of shellac as a means of securing an oil-tight joint, and perhaps no substance is more commonly used for this purpose when the joints to be made are between the sections of a crankcase of a motor, or the gear-case of transmission or rear axle mechanism, etc.

It Also Is a Well-known Fact that it is a dirty, sticky substance to handle, owing to the fact that means rarely are provided so it may be used without getting on the hands, where it dries quickly, and is most difficult to remove.

If a Bottle or Can of Shellac Is to be Prevented From Drying Up, the receptacle in which it is kept must be corked up when not in use; and if a brush is employed in its application it must be adjustably mounted in the stopper, or removed and carefully cleaned with alcohol or varnish-remover immediately after its use, otherwise the varnish will dry upon it and render it as useful as a stick.

A Stick, By the Way, is the Most Common Means of Applying Shellac in the motor car repair shop.

There is a Better Method, though, which is now employed in one shop.

It Consists of a Wooden Stopper which is hemispherical or egg-shaped, with a handle, as shown in Fig. 3.

When a Workman Wishes to Spread a Coat of Shellac Upon a Gearcase Cover, or a gasket, he has but to invert the bottle with the stopper in place, then remove the stopper and roll the large end over the surface to be smeared, and a coat of shellac is left in its wake.

The Handle and the Hands May be Kept Clean, no cleaning of brushes is required and there is no waste of shellac.

TO PREVENT OIL FROM WORKING OUT OF TRANSMISSION.

It Will Often Be Found that a Good Deal of Oil Escapes From the Cover of the Transmission Case owing to the washer being defective. It is very easy to cut a new washer out of good brown paper, but occasionally I have seen people take a long time to perform this simple operation and then make a very defective washer in the end. The most simple, and by far the most accurate method, is to remove the lid from the case and turn it upside down on some flat surface where it can be held firmly.

Take the Sheet of Brown Paper and lay it on the cover, and then with a small, flat hammer gently tap the paper all round the edge of the cover. If there are any curved corners it is as well to employ the round face of a riveting hammer, but practically any ordinary small hammer will do the work well enough. The plan is shown in the illustration (Fig. 4). The outside can thus be cut away and then, while the paper is still held in position, the inside can be cut out. The holes for the bolts should be similarly cut, using the round face of the riveting hammer for the work. By this means a perfectly fitting washer is easily and quickly made, and this can be dropped over the bolts from the gear-case and the lid placed over it. A little oil should be smeared on each side of the paper in order to prevent the washer sticking to the middle of the case, which it will be certain to do if the paper be pressed between the surface in its dry state.

A Gear-case Packed With a Washer Thus Made Will Be Found Absolutely Oil-tight, except at the ends of the shafts, at which points there is almost always a certain amount of leakage. Personally, I believe in using a mixture of thick oil and grease in preference to plain grease, as the oil seems to work better and certainly ensures that the bearings will not run hot. But it is useless employing it unless the cover be a good fit and is carefully packed. A good washer of medium thickness brown paper, properly cut as directed, will practically stop all tendency in this direction. Washers of sheet asbestos can be most accurately cut in the same manner.

REPAIRING A CRACKED CYLINDER.

Notwithstanding that the Car Is Carefully Housed in Winter, or Some of the Compounds Advised to Prevent Freezing are Used, a Cylinder Cracked By the Frost Is Not Unknown. If the crack is in the jacket of the cylinder, and not in the head or round the water space of the valves, it can be patched.

Fig. 5, chart 165, Represents a Cylinder Cracked by Frost. The dark line shows the crack. As cracks have a habit of extending, a small hole should be drilled at each end of the crack or a little beyond it, for the crack may go further than is visible to the eye. A ¼ inch taping hole should be drilled and tapped, and a screw inserted and screwed home, and the end filed off flush with the metal. Then a piece of stout sheet copper, not less than 1-12 inch thick, should be cut out covering the crack and allowing ⅝ inch or ¾ inch if it be a long crack, all round the crack. This must be bent to fit the cylinder, and fixed down with a number of 3-16 inch or ¼ inch screws, putting a piece of canvas smeared with red lead, putty, or thick oil paint under the copper. The patch may leak a little at first, but will probably "take up" in a few days.

A Plan Which Would Probably Answer if the cylinder had no excrescences on it, would be to use thinner copper or sheet iron, and bind it on with steel wire from end to end of the patch plate.

Cracks Are Said to Have Been Stopped By Pouring Into the Jacket or Water Space a Strong Solution of Salammoniac. This causes rust to form and fill up the crack. That rust has a wonderful power of fastening iron together every one must have noticed who has had to unscrew a nut that has been long exposed to the weather. The holes drilled and plugged at ends of crack must not be omitted.

HOW TO SOLDER.

A Soldering Iron should be bought. It is a wedge-shaped block of copper, fitted in an iron fork with a wooden handle. To use it, the "bit" is placed in a clear fire, or gas, or blow pipe torch burner till it is hot enough to use (See Figs. 1 and 2, Chart 166.)

If the Iron Is a New One, it must be tinned. When hot, file off the scale on both sides and ends for a quarter of an inch from the tip, so that the metal be clean and bright, dip the nose in the soldering fluid for a second, and then apply it to the stick of solder. A globule will melt off on to a piece of dry brick or tinplate which must be ready to receive it. Rub the nose of the bit in this solder, which will adhere to it as quicksilver does to zinc. The bit can then be used.

To Solder Two Surfaces they must be clean and dry and rubbed with emery cloth. Old work may require cleaning with hot water and soda to remove grease, and the solder runs along the joint and binds the two together. To clean the metal and allow the solder to work freely, a flux must be used.

The Soldering Fluid Generally Used is made by placing a few bits of scrap zinc in a jar and pouring on it a few ounces of commercial hydrochloric acid (spirits of salts).

Violent Ebullition Occurs, and as the fumes given off are injurious to the lungs, and also attack any bright metal work, the jar should be placed in the open air. In five or ten minutes the bubbling ceases, and the fluid can then me used.

There Are Several Soldering Fluids Sold, some in the form of liquid and some in the form of paste.

For Electrical Work Resin Should Be Used, as the action of electrical current sometimes causes a resistance to be set up in a joint soldered with spirits of salts.

Copper, Being a Good Conductor of Heat, requires care in soldering. It is best, after cleaning the copper, to heat it in a gas or spirit flame and tin it by rubbing the bit, with plenty of solder, over the part required to be soldered.

If a Gasoline Pipe Leaks, the crack must be cleaned and soldered up, If the crack appears lengthways in the pipe, one of the best ways to repair it is to bind round the pipe, after it has been tinned some copper wire, and solder this on to the pipe.

Gasoline Pipes Sometimes Get Loose in the sockets of the unions. This is due to bad fitting, and shows there is not sufficient elasticity in the pipe; it is too rigidly held. The screwing up of the union strains the pipe, and the vibration on the road causes the pipe to give way at its weakest point, namely, the soldered joint. If the pipe gets loose more than once, it shows there is something wrong.

A Longer Pipe Should Be Put In, having a U bend in it or a complete circle to give elasticity. The U bend or circle should lie horizontally, with a drop towards the carburetor, otherwise there may be what is called an air-lock, in the pipe, and the gasoline will not pass through.

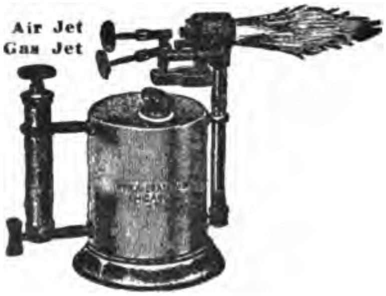


Fig. 1—A Blow Pipe Torch
Very useful around any shop

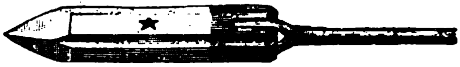


Fig. 2—A Soldering Iron
(Handle not shown)

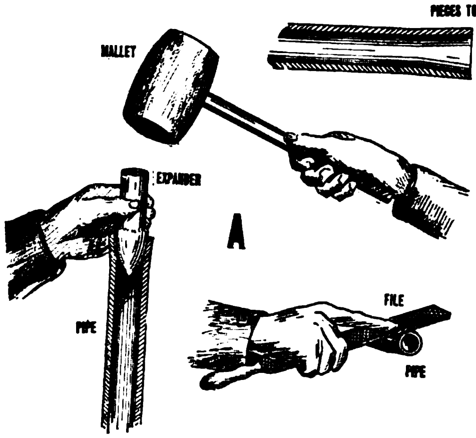


Fig. 3—Preparing to Join Two Pieces of Pipe

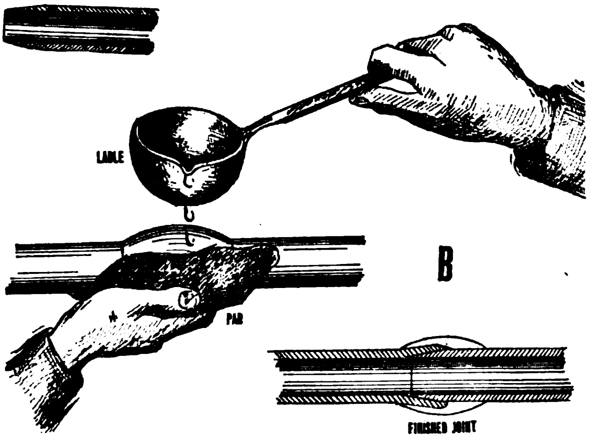


Fig. 4—Wiping a Joint

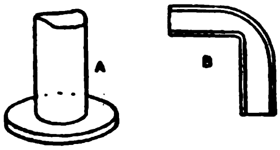


Fig. 5—Brazing a Flange

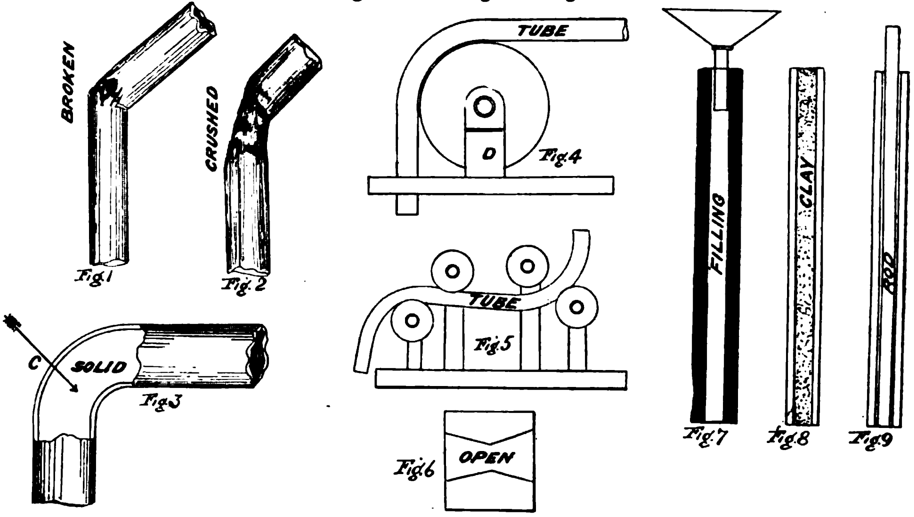


Illustration No. 6—Bending Tubing

CHART No. 166

If the Carburetor Float Leaks, if of metal, it must be repaired with solder. Sometimes it is difficult to find the leak, and if the leak is very small it would take a considerable time to get the gasoline out. The best way is to drill a small hole in the float to get rid of the gasoline; by blowing in to the float at this hole, and smearing it with soap suds, the bubbles will show where the leak is. When this is made tight, the drilled hole must be closed with a globule of solder.

The Soldering Iron Must Not Be Allowed to Get Red Hot, as the tin will be burnt off, and the tinning process must be repeated.

The Reader Should Practice Soldering at Leisure, so that when he requires to use the bit for work on the car he should know how to do it. For practice, he will very likely find some leaky water cans in the house or in his garden. If a can has a bad hole in it, a patch must be put over it. But he must remember that the surfaces must be perfectly clean. Sometimes, especially in old work, the emery cloth will not get a clean surface. A dark spot may be a depression which the emery cloth will not reach; the file must then be used. No soldered joint should be exposed to a great strain. It is quite easy to bend a stick of solder and then break it, hence tin soldering is called soft soldering.

HOW TO SOLDER ALUMINUM.

There are various compounds on the market for soldering aluminum, but this operation depends more on the workman than on the solder, and unless considerable experience has been had it is probably better to purchase solder than to attempt making it.

Zinc Can Be Used, but does not form a very strong joint.

Tin Can Also Be Used, is more nearly the color of aluminum, is stronger than zinc, but is very difficult to work. A small proportion of phosphor tin added to pure tin makes it work more readily and is the basis of most aluminum solder.

The Chief Difficulty In Soldering Aluminum is that the Heat Is Dissipated so rapidly that it Cools the Soldering Iron, and furthermore aluminum oxidizes instantly upon exposure to the air.

This Extremely Thin Film Effectually Prevents a Perfect Union being made. If the parts are well heated and melted solder kept hot while the iron is allowed to stand on it, the surface can be scraped beneath the melted solder by the point of the soldering iron, thus preventing to a certain extent the oxidation. In this way the metal can be tinned.

When Both Parts to be Brought Together Are Well Tinned, the parts can be united with some chance of success, nitrate of silver, rezin, or zinc chloride being used as a flux.

A Soldering Tool of Nickel gives more satisfactory results than a copper one, as the latter alloys with the tin and soon becomes rough.

CLEANING THE METAL.

If the Surface Is of Such a Shape that it Cannot Be Readily Cleaned by Scraping, it can be cleaned by dipping it into a solution of nitric acid in three times its bulk of hot water containing about 5 per cent. of commercial hydro-fluoric acid. This causes a slight action on the surface of the metal as shown by bubbles. Rinse the metal after removing from the acid bath and dry in hot sawdust.

ALUMINUM-SOLDER.

The Following Formula, in the hands of a competent man, can be used to unite aluminum or aluminoid parts:

Tin—10 parts.
Cadmium—10 parts.
Zinc—10 parts
Lead—1 part.

The Parts to be United Must Be Thoroughly Cleaned and allowed to stand two or three hours in a strong solution of Hypo-Sulphate of soda before being operated or cleaned in the acid bath described above.

BRAZING.

Brazing or Hand Soldering Is Infinitely Stronger than Soft Soldering. It is by brazing that bicycle frames are built up. Brass cannot be brazed, as the heat would melt it, but for iron and copper it is very useful. Brazing is often done in a smith's forge, using coke or charcoal as fuel. Cycle makers use a gas blow flame. This consists of two parallel pipes—one for gas and one for air. The air, which issues under pressure, causes a strong and very hot flame. The air pressure is produced by a small bellows worked by the foot. Coke is used in the hearth of the forge, for it is generally used in conjunction with a forge.

The Hard Solder, As It Is Sometimes Called, is a brass that melts at a low, red heat. It is generally bought in packets, and is in grains, about the size of a pin's head. Brass wire is also used. Being wound round the part to be brazed, it melts and runs into the joint. The flux used for brazing is powdered borax.

BRAZING A FLANGE.

If It is Desired To Braze a Flange on to a Pipe, the flange is placed on the pipe and the pipe expanded by hammering till it is a tight fit. This is necessary, as it may shift its position in the act of brazing. The flange and pipe (A, Fig. 5) are put in a clear fire in the forge. Then as it gets hot the spelter, with borax, is sprinkled round the joint, which melts and finds its way into the space between the pipe and the flange. If the reader has a gas or petrol blow pipe it will make the work easier, as the heat can be directed where required from above. When cool the superfluous brass is filed off. In many cases it is impossible to keep the two pieces of metal in the correct places in the forge, therefore a pin or rivet must be put in, so that they cannot shift.

If an Exhaust Valve Has Not Sufficient Lift, a piece of sheet metal of the required thickness may be brazed on the end of the stem. The metal should be larger than actually required, and the outstanding edges afterwards cut away.

Broken Wrought-Iron or Steel Levers can be Mended by putting a patch on each side with rivets, like railway fish plates and brazing together. The spelter finds its way into the smallest cracks and joints, and makes a good job.

JOINING TWO PIECES OF PIPE—CALLED "WIPING A JOINT."

The Pipe Is First Cleaned and ends slipped together, as shown in Figs. 3 and 4, Chart 166.

The Solder is melted in a ladle and is poured around the joint. A pad of calico or velvet is held in the hand under the pipe, as shown, the surface of this being well greased with tallow.

It Need Not Be more than three or four inches square and about one-quarter inch thick, and the bottom layer may be of asbestos sheet so that there will be no possibility of the molten metal burning through and injuring the hand of the operator.

As the Molten Solder Is Poured on the Pad, it is wiped around the joint until it is heaped up all around the point of junction, the amount of metal used depending upon the size of the pipe or tubing joined.

As the Metal Is Applied and wiped smooth with the pad before it has a chance to harden, the finished point has a neat appearance.

While Copper or Brass Pipe may be joined without difficulty by ordinary methods of soldering or brazing, the wipe method is about the only practical way to couple lead tubing.

BENDING TUBING.

That Little Problem of Bending Metal Tubing Is One that Comes up Quite Often in the motor vehicle repair and construction shop. Often when you undertake to bend some of the new kinds of metal tubing you are surprised to have it break off as at illustration 6, Fig. 1, even though the usual precautions may have been taken to prevent a fracture of this nature. Unless the tube is supported inside, the walls are going to break as in this cut, or they are going to collapse as in Fig. 2. If you will look into the junk heaps of any shop you will find numerous examples of the wreckage of defective bending of tubes. There will be light weight tubes, heavy weight tubes, steel tubes, iron tubes and tubes of all kinds.

First of All, it is best to determine the character of the composition of the tubes. Many tubes of different manufacture are made and finished nearly alike and you cannot very well determine what procedure to follow when desiring bends or scrolls in the same. But the file test or acid test will quickly remedy this. Or even the point of a cold chisel will do to determine the nature of the metal. Then you can work accordingly.

It Is Odd, But Oftentimes Men of Experience Proceed to make one or more bends in tubing without first ascertaining the character of the metal. The result is that some of the brittle tubes are broken short off. Some tubing can be bent even without packing. due to the elasticity of the metal and to properly heating the metal before bending. But nearly all of the tubes or pipes for bending in the shops need filling to prevent the collapsing of the pipe walls, making the interior solid as at (C), Fig. 3. With a solid inside, it is possible to manipulate the tube or pipe as desired. It is not a good idea, however, to resort to the vise, the anvil or the hammer for bending, nor can a wrench be used to good advantage in effecting a curve in the tube or pipe in hand. These methods are "makeshifts" and are usually non-eflective.

Filling the Pipes. In every up-to-date shop may be seen different designs of tube and pipe bending contrivances. Some of the apparatus is very simple. Much of it is crude. There are first-class tube and pipe-bending machines on the market and some of the motor vehicle repair men have secured such machines. But the majority of mechanics have rigged up affairs of their own design.

In Fig. 4 Is a Drawing of a Common Style of Tube and Pipe Bender. There is the metal wheel, which can be any diameter from three inches up to a foot, and can be changed at will, making it a useful machine for pipe and tube bending, because any kind of a curve can be described on it. The wheel should be wide enough to allow plenty of surface action. Often the wheel is slightly grooved, thereby assisting to support the work. The wheel bears in the stand (D) on a shaft. The stand fits tightly in the base board.

The Tube for Bending Is Properly Prepared or Filled and one end is locked into the bore in the base board. Then pressure is exerted and the tube is doubled over on the form of the wheel as shown. In case it is necessary to form the tube into the shape of a letter "S" a device like in Fig. 5 can be used.

Fig. 6 Is a Handy Contrivance, consisting of a block of metal through which the cone-shaped bore is made. This block is secured in place and the pipe or tube for bending is simply passed through. Then muscular power is applied and the bend effected by hand.

HARDENING SMALL STEEL PARTS.

Car Owners Sufficiently Versed in Mechanical Practice to do their own small repairs occasionally wish to know the most convenient way of hardening steel parts, such as small pinions, bushes, nuts, cotters, and similar articles. Certain parts are better made from mild or Bessemer steel rather than from tool steel; good quality iron also may be used.

It Is Not Difficult to Harden Such Parts on the surface, leaving the mass or interior of the metal soft. The part in this condition is not so liable to break under the shock or wedging action.

It Is Possible to Case-Harden Small Pinions quite well by bringing them to a uniform bright-red heat and plunging them into finely-powdered yellow prussiate of potash, repeating the operation three or four times, and finally plunging into clean cold water whilst still at a red heat. The mild steel absorbs carbon from the potash to a depth of about half a millimeter, and this surface hardens perfectly on the final cooling. Nuts so treated resist rough usage with the spanner much better than an ordinary soft-surface nut.

In Treating Parts of this Class it is, however, important to remember that the threaded part should be filled up with clay, so that it does not come in contact with the carbonising material; otherwise it will be certain to be spoiled. Any roughness of the surface, such as on the teeth of pinions, can be smoothed off with emery cloth wrapped over a thin flat file. Parts made from tool, or high carbon steel, are readily hard-

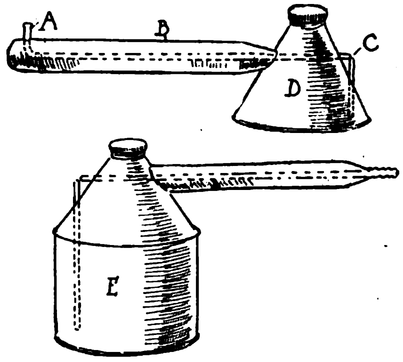


Fig. 1—A Home Made Paint Sprayer for Spraying a Radiator

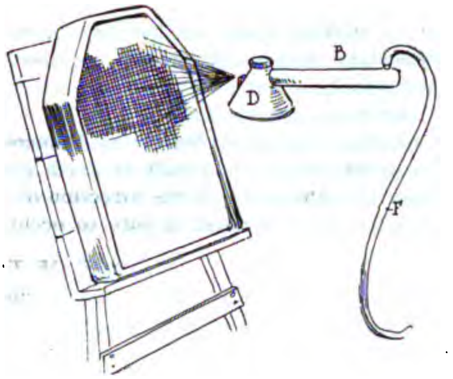


Fig. 2—The Device Spraying a Radiator

Painting a Radiator

It is very difficult to paint a motor car radiator quickly and thoroughly with a paint brush; but a very satisfactory job can be quickly done with a spraying outfit. A very simple and home-made device is here illustrated. It consists simply of a construction such as is shown in fig. 1, in two sizes and designs, which comprises a can for the paint, consisting of a mixture of lampblack and turpentine, a hollow cylindrical tin handle attached to the can, an air pipe passing through the handle and through the can, as indicated by the dotted lines, and another similar pipe or tube extending downward at right angles from the one end of the horizontal tube into and near to the bottom of the can, as is also indicated by dotted lines. It is a simple adaptation of the principle employed in most atomizers. When a stream of air is forced through the air tube passing through the handle and directed across the opening at the top of the vertical tube the fluid from the inside of the can is drawn up and sprayed onto whatever object upon which the stream is turned.

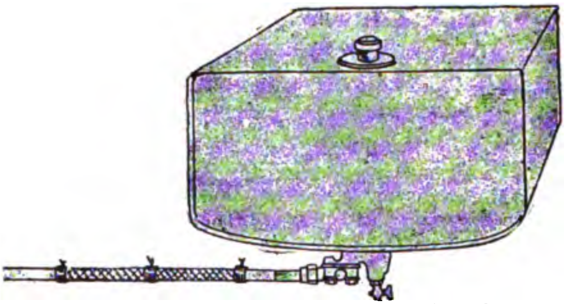


Fig. 3—A Simple Method of Emergency Repair for a Broken Gasoline Pipe

Fixing a Broken Gasoline Pipe on the Road

A Broken Gasoline Pipe Has Been Fixed Temporarily when out on the road by cutting off about two inches of the gas pipe tubing and placing on each end of the broken pipe and wrapping it well with tape.

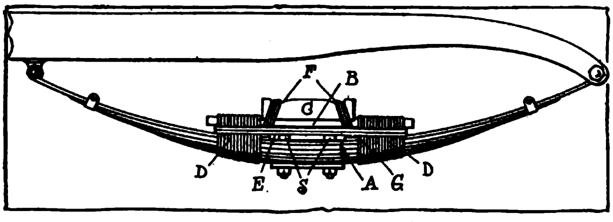


Fig. 4—A Temporary Spring Repair

Repairing a Spring

In fig. 4 an illustration is given, showing how a temporary repair was made upon a spring whose three lower leaves were broken on striking an apparently shallow hole in the road which was filled with water. After the break A occured, the car was slowly driven to the next farmhouse, where some 2 by 4-inch wood, a saw and some baling wire were obtained. The short block E was cut off first and two shallow grooves S were cut into one side of it so that it would clear the spring clips and rest flat on the central portion of the top spring leaf. The sides of these slots were cut with a saw and then finished up with a cold chisel carried in the tool kit of the car. The piece B then was cut off and nailed to the short piece E, so that the sides were flush and its ends extended over the ends of the short block equally distant on either side. The top block C, which was made just a trifle longer than the short bottom block, was cut off and slotted in the same manner as the under block, only the slots were not so wide and farther apart as designated by the letter F. This block then was nailed to the long piece, centrally located with the slots up; The frame of the car was then jacked up so that the injured end of the spring was a little above its normal height; and the blocks were set in position as shown and securely bound into place with the wire D. When this was done a few strands were wound about the two top pieces, as at G, to add to their security; then a few more strands were bound laterally around the whole, as at L. This completed the temporary repair. (Motor Age.)

ened by making them red hot and plunging them into cold water. The correct heat is important, because if the parts be heated to a very bright red, they may be spoilt or decarbonised, and if to a white heat, certainly so. On the other hand, if made barely red, the parts will not harden.

Another Important Matter to Remember in Hardening Parts, such as pins, drills, and cotters, where the length is much greater than the diameter, is that they must be plunged into the water in the direction of the length—straight down and not horizontally—or twisting or warping is sure to occur.

THE ART OF TEMPERING STEEL.

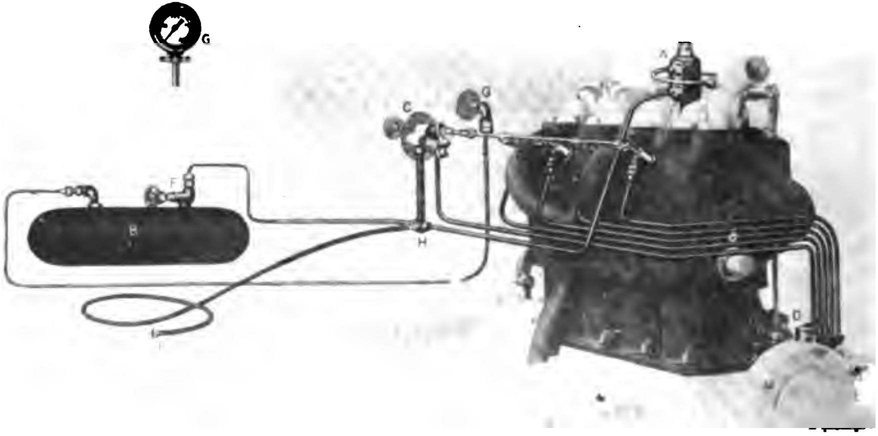
A Spring Can Be Hardened and Tempered Nicely By Heating Uniformly to Redness and Plunging into Ordinary Engine Lubricating Oil; then withdrawing and burning off the oil in the flame, that is, to hold the spring in the flame till the oil has just flashed off and then withdraw it. It is useful to know how to "let down" a hardened part.

One Often Notices on Exhibition chassis gear wheels and similiar parts which have a rich deep yellow surface coloration. This denotes a particular degree of tempering; the parts are made less hard and brittle than when they come out of the water, which leaves them "dead hard."

A Part to Be Tempered Must First Be Cleaned up and polished to a fair surface before making "dead hard" in the way described.

After This They Have to be Lightly Cleaned up Again which is quite easily done with fine emery cloth. There are then several ways of proceeding.

A Very Small Part Can Be Fixed to a Piece of Steel Wire and very cautiously held in the bunsen flame (or, the blowlamp flame) till the polished surface takes on a uniform straw color. The instant this is attained the part must be plunged into water. The part can be kept in the flame longer till a deep straw color merging into purple is attained and then cooled off. It will be slightly softer than before. It can be further "let down" to a blue color, when it will be soft enough to file with difficulty. Drills and small tools can be tempered quite well in a flame. Larger parts are better tempered on an iron plate on which has been placed a thick layer of fine sand and the flame allowed to play underneath. This ensures the part being uniformly tempered.



THE AIR STARTER ON THE CHALMERS.

A—Check valve. B—Storage tank. C—Dash push valve. D—Distributor. E—Cylinder valves. F—Shut-off valves. G—Pressure gauge. H—Valve for attaching tire inflator. I—The end of tube to connect with tire.

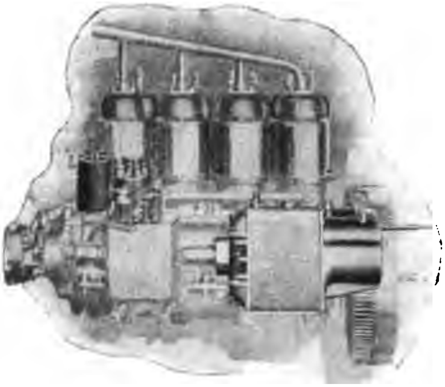
Fig. 3—Showing the features of the compressed air self-starting device which is a part of the regular equipment of the Chalmers model 36. In this system air is forced from No. 1 cylinder through the check-valve A and suitable piping to the storage tank B carried under the body of the car. When it is desired to start the motor the valve C on the dash is opened, and air released from the tank is conducted to the distributor D, which delivers it to the cylinders at E. G is a gauge on the dash, H the tire hose connection, and I the tire valve connection.

STARTING A MOTOR BY AIR (AS USED ON THE CHALMERS).

The self-starter is not an accessory but an intergral part of the power plant. In this system compressed air is forced from No. 1 cylinder through a suitable check-valve and piping to a storage tank carried under the body of the car. When it is desired to start the engine a valve conveniently located on the dash is opened and air released from the tank, which is conducted to a distributer, operating upon the same principle as the commutator used on almost all cars having double ignition systems. By means of this distributer the compressed air is delivered into the cylinders, which are ready for the working stroke in their order of firing; thus the motor is operated by compressed air instead of cranking.

It is claimed that this new feature of the Chalmers 36 has been tested on three different cars in more than 20,000 miles of driving, and it never once failed to work. Some idea of the power of the self-starter may be gained from the claim that it is possible to set the gears in second speed, shut off the ignition system and actually drive the car from stand-still, using compressed air to run the motor.

THE "DELCO" STARTING, IGNITION AND LIGHTING SYSTEM.



Another Starting Device is known as the "Delco," which is used on the 1912 Cadillac. This is in the shape of a combined starting, ignition and lighting system.

The Delco Starting and Lighting System consists essentially of two units, namely, a motor generator and a storage battery. Accessories are added such as a cut-out device, controlling switches and a regulator.

The Motor Generator is so attached to the engine that by means of suitable operating means it can be connected to the fly-wheel of the engine and simultaneously converted into a motor to supply power for turning the engine by means of a train of reducing gears. A storage battery supplies current, at 24 volts, for operating the motor to turn the engine.

After Performing Its Functions as a Motor the motor is disconnected from its geared connection to the fly wheel, and is automatically connected to the magneto shaft of the engine by means of a ratchet clutch which drives it at engine speed. At the same time the machine is disconnected from the fly wheel the electrical connections are automatically re-arranged so as to convert the machine into a shunt generator, which, upon being driven by the engine, supplies current to the storage battery for use in future starting operations and for lights and ignition.

There Are No Switches to Operate in connection with the starting of the engine; the only manually operated switches are those used for turning the lights on and off.

The System Is Normally Operative as a Generator System Which Will Supply Current for Charging the Storage Battery, operating lights and ignition, and can only be converted into a motor for turning the engine when the latter is not in operation. Suitable safety devices have been provided which render the controlling mechanism inoperative while the engine is running.

THE IGNITION SYSTEM.

In Developing the Ignition System it was impossible to place the breaker box and magneto distributor in the generator proper because of the fact that the generator is used to crank the motor at one speed, and to be driven from the engine at another speed which holds it in no definite timed relation to the crank shaft.

The Condenser Is Mounted Directly Onto the Distributor, and the high tension step-up transformer or coil is located in a bracket at the side of the distributor.

This System Takes Current From the Storage Battery when the speed of the engine is below 300 r. p. m., and above 300 r. p. m. the current is taken from the armature of the generator. The current goes directly from the generator through the breaker box of the distributor, and through the primary of the coil or transformer. The high tension wire is brought off the coil to the center of the distributor, and the high tension current distributed to the spark plugs the same as the regular Delco distributor.

* MISCELLANEOUS EMERGENCY REPAIRS.

Running for Even a Short Distance on a flat tire will destroy the shoe and tube; stop the car at once and make the necessary repair or replacement.

Running Without the Tire on the Rim Will Damage The Grooves, and make other trouble; if no spare parts or repair kit are at hand, the rim may be protected for slow running by binding it with heavy rope.

When a Spring Breaks, place a block of wood between the axle and body padding it with burlap or something of the sort, bind the frame and axle togetehr to hold it in place, and go slowly.

Wire Hair Pins and hat pins are invaluable for cleaning out small passages, as in the carburetor and lubricator, for instance, and for avariety of uses.

A Small Hole in Brass or Copper Pipe may be permanently repaired by winding light copper wire tightly around the pipe and over the hole, soldering it in place.

When Tightening up Bolts or nuts, do not strain them by using a wrench that gives too much leverage; for small nuts use a small wrench, as a long handled one would give such leverage that the threads would strip.

In Using a Hammer, do not pound too hard, nor always pound in the same place.

In Separating a Cylinder from the Crank Case, for instance, hammer lightly all around, not heavily in one spot.

Wherever it is Possible, do not hammer direct on the metal; hold a block of hardwood, or a chunk of copper, between the hammer and the work.

When a Nut is Stuck on a Bolt so that it cannot be moved without danger of stripping the threads, soak it in kerosene, which has the property of entering the smallest crevices.

After a Few Hours the nut will be loose enough to remove.

Another Plan is to hold a hot poker against the nut, counting on the expansion of the metal to loosen it.

When It is Necessary to tow the car, use two ropes, attaching one to each side of the front axle.

Cross the Ropes before attaching them to the car in front, so that they form a letter X, as this will prevent the rope from going slack when making turns and make towing easier.

If the Engine Has a Detachable Crank, or the starting crank connection breaks so that the engine cannot be started in the usual manner, the engine may be started by pushing the car.

Sit in The Car, throw in the high speed, switch on the ignition circuit, and release the clutch.

Holding the Clutch Out, have the car pushed or towed until it is going at a rate of good speed, when the clutch should be gently thrown in.

The Momentum of the Car Will Act on the Crank Shaft, and get it going, but the instant that the engine starts the clutch should be thrown out, as otherwise the horse that does the towing will be run down.

The Same Thing Can be Done While the Car Coasts down hill.

Another Method of starting the engine when the starting crank is lost, is to use the change speed gear and wheels.

Jack Up One of the Rear Wheels, blocking the front one..

Engage the High Speed Gears, switch on the ignition, throw in the clutch, and then turn the jacked up wheels forward by hand.

This Will start the engine.

Throw Out the Clutch before taking out the jack—otherwise the car will leave you.

If a Cone Clutch Slips, carbide dust, as used in your gas generator, will make it hold temporarily. If the cone clutch is lined with leather and it has been faced off and still will not hold, then try cutting notches across the leather face.

For a Digest of all troubles; how to find the cause and remedy and questions asked and answered. See page 358.

HOW AND WHERE TO GET INFORMATION.

By addressing the Publisher of This Book; addressing your correspondence to A. L. Dyke, Publisher, St. Louis, Mo., "Information Department," and enclosing stamped and self-addressed envelope for reply, we will gladly furnish you with any information we can.

IF YOU WISH TO LEARN MORE ABOUT MAGNETOS; HOW THE DIFFERENT MAKES ARE CONSTRUCTED AND HOW TO SET THEM, WRITE THE MANUFACTURERS BELOW FOR THEIR CATALOGUE.

C. F. Splitdorf Co., 261 Walton Ave., New York, N. Y.
Bosch Magneto Co., 223 W. 46th St., New York, N. Y.
Remy Magneto Co., Anderson, Ind.

There are a lot of other manufacturers, who can be found in the advertisements of the various trade papers.

I WOULD ADVISE EVERY REPAIRMAN TO GET ALL THE INFORMATION HE CAN ON THE CONSTRUCTION OF THE VARIOUS MAKES OF CARBURETORS—WRITE THE DIFFERENT MANUFACTURERS FOR THEIR CATALOGUE—HERE ARE A FEW:

Wheeler & Schebler, Indianapolis, Ind.
Stromberg Motor Device Mfg. Co., 64 E. 25th St., Chicago, Ill.
G. & A. Carburetor Co., 244 W. 49th St., New York, N. Y.
Findeisen & Kopf, 2100 So. Rockwell, Chicago, Ill.
Breeze Carburetor Co., 250 South St., Newark, N. J.
Byrne-Kingston Co., Kokomo, Ind.
Carter Carburetor Co., 914 N. Market St., St. Louis, Mo.

There are a number of other manufacturers to be found in the ads. of trade papers.

REPAIRMEN WHO WISH TO ADD VULCANIZING, WRITE TO FOLLOWING FIRMS FOR CATALOGUE:

C. A. Shaler Co., Waupun, Wis.
Rice & Dayton Co., Cedar Falls, Iowa.
Haywood Fire & Equipment Co., Indianapolis, Ind.

Others can be found in ads. in trade papers.

AUTOMOBILE SUPPLY CATALOGUES ARE FULL OF INFORMATION.

There are so many Auto Supply Houses it would be impossible for us to list them. Subscribe for one of the trade papers below and read the ads. of the various supply houses.

BY ALL MEANS SUBSCRIBE FOR ONE OR MORE TRADE PAPERS. HERE IS A LIST OF THE LEADING ONES:

"Motor," 381 Fourth Ave., New York, N. Y.
"Cycle & Auto Trade Journal," Philadelphia, Penna.
"Dealer & Repairman," 24 Murray St., New York, N. Y.
"Horseless Age," 250 W. 54th St., New York, N. Y.
"Motor Age." 1200 Michigan Ave., Chicago, Ill.
"Automobile," 239 W. 39th St., New York, N. Y.
"Auto Review" Pub. Co., 16th and Washington Ave., St. Louis, Mo.

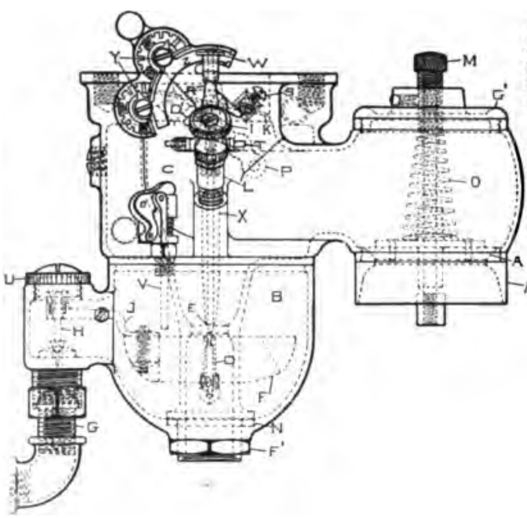


Fig. 1—Adjusting a Model "L" Schebler Carburetor

Before Adjusting the Carburetor Make Sure That Your Ignition Is Properly Timed, and that you have a good hot spark at each plug; that your valves are properly timed and seated, and that all connections between your intake valves and carburetor are tight, and that there are no air leaks of any kind in these connections.

ADJUSTING FOR SLOW SPEED.

In Adjusting the Carburetor, first make your adjustments on the auxiliary air valve M, so that it seats firmly but lightly at A; then close your needle valve by turning the adjustment screw D to the right until it stops.

Do not use any pressure on this adjustment screw after it meets with resistance. Then turn it to the left about a turn and a half and prime or flush the carburetor by pulling up the priming lever C and holding it up for about five seconds.

Next, open your throttle about one-third, and start the motor; then close your throttle slightly and retard your spark and adjust throttle lever screw S and needle valve adjusting screw B, so that the motor runs at the desired speed and hits on all cylinders.

ADJUSTMENT FOR MEDIUM SPEED.

After Getting a Good Adjustment With Your Motor Running Idle, do not touch your needle valve adjustment again, but make your intermediate and high-speed adjustment on the dials Y. Adjust pointer on the first dial, from figure No. 1 toward figure No. 3, about half way between.

Advance Your Spark and Open Throttle So That the Roller on the Track Running Below the dials is in line with the first dial.

If the Motor Backfires With the Throttle in This Position, and the spark advanced, turn the indicator a little more toward figure No. 3; or if the mixture is too rich, turn the indicator back or toward figure No. 1 until you are satisfied that your motor is running properly with the throttle in this position, or at intermediate speed.

ADJUSTMENT FOR HIGH SPEED.

Now, Open the Throttle Wide and Make Your Adjustment on your lower dial for high speed in the same manner as you have made your adjustments for intermediate speed on top dial.

It Is Found That in the Majority of Cases in Adjusting This Carburetor the tendency is to give too rich a mixture. It is suggested and recommended in adjusting the carburetor, both at low, intermediate and high speed, that you cut down the gasoline until the motor begins to backfire, and then increase the supply of fuel, a notch at a time, until the motor hits evenly on all cylinders.

Do Not Increase the Supply of Gasoline by Turning the Needle Valve Adjusting Screw More Than a Notch at a Time, in your low-sped adjustment, and do not turn it any after your motor hits regularly on all cylinders.

In Making the Adjustments on the Intermediate and High Speed Dials, do not turn the pointers more than one-half way at a time between the graduated divisions or marks shown on the dials. By following these instructions the adjustment should be satisfactory.

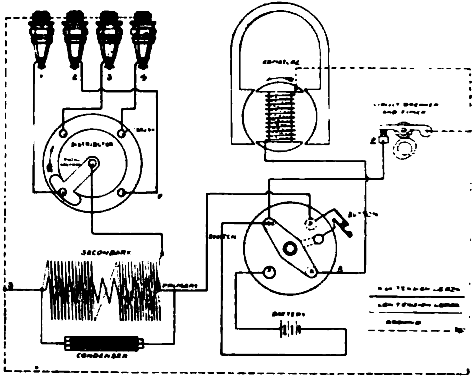


Fig. 2—Diagram Explaining the Splitdorf Model "F" System of Ignition.

This diagram will explain how a low tension magneto (single wound armature) is used in conjunction with double wound secondary coil.

A Feature of This System is that the engine may be started "on compression" by turning switch to battery and rapidly pushing the button on the front switch.

The Coil Is Not Equipped With a Vibrator, and this rapid opening and closing of the circuit takes the place of the contact breaker or magneto.

It Is Understood that a charge of gas must be in one of the cylinders, otherwise the engine must be cranked and the contact breaker or magneto will act instead of a vibrator.

After Car Is Started the switch is turned on to the magneto side.

The Magneto Low Tension Current is carried through the non-vibrating coil and intensified to a high pressure.

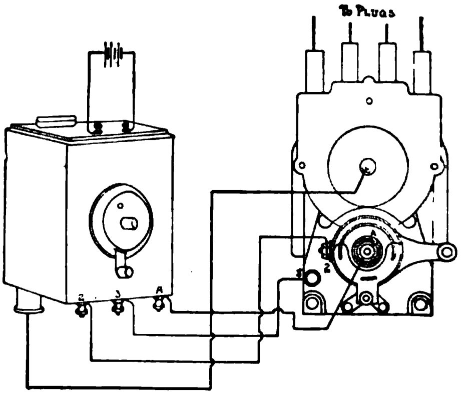


Fig. 3—Diagram Explaining the Splitdorf Model "T" System of Ignition

The Explanation of the Adjustment of the Model L Schebler Carburetor, by Mistake was Omitted from Carburetor Subject, also the Splitdorf Diagrams of Wiring

CHART No. 168

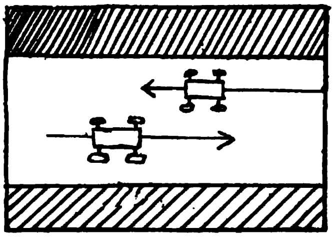


Fig. 1—Cars going in opposite direction; keep well to the right.

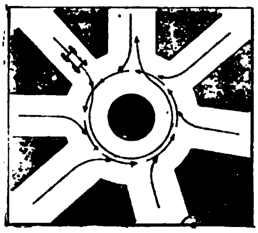


Fig. 2—On approaching a circle; arrows point the way.

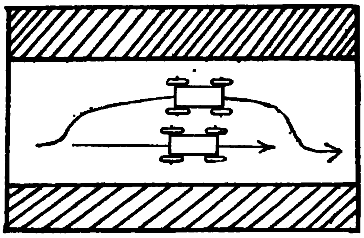


Fig. 3 One car passing another vehicle going in the same direction

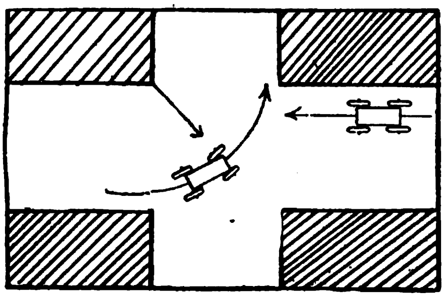


Fig. 4 In turning corners with a car coming, use signal with your hand to indicate the direction you intend to go and for him to slow up. Always observe a central point O in the intersection of streets and clear it when turning.

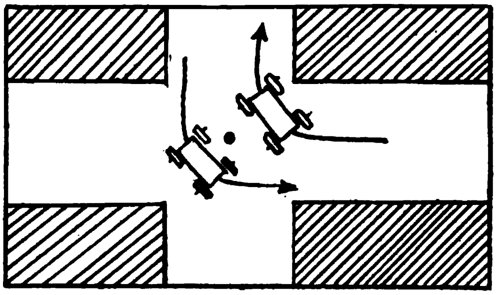


Fig. 5—The driver of a vehicle turning to the left from right hand side; should pass the center of the street intersection before making a turn. In case he wishes to make a right hand turn he should hug curb as closely as possible.

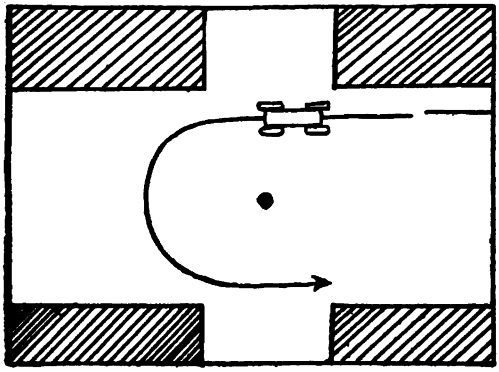


Fig. 7—In turning, go to far corner, then make a wide swing to turn.

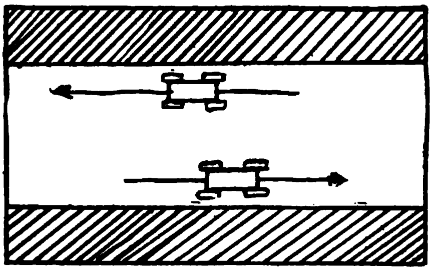


Fig. 6—In stopping; do not face car in wrong direction. Stop with the right side of car to the curb.

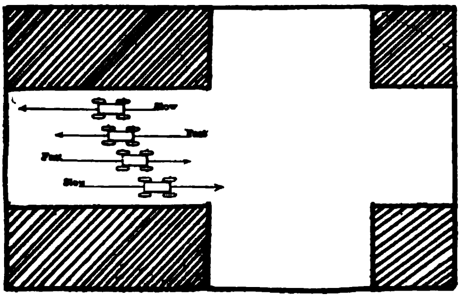


Fig. 8—Slow going vehicles; keep close to curb.

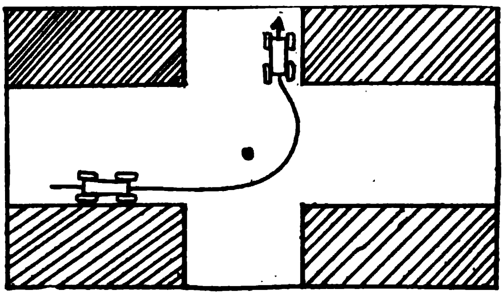


Fig. 9—How an auto should turn a corner.

Rules of the Road

CHART No. 169

INSTRUCTION No. 36

RULES OF THE ROAD:—Rules for Driving, Passing and Turning. Storage of Gasoline. Supplies and Tools for Touring. How to Select a Car. Insurance.

The Driver of a Car should be careful to observe the rules of the road, for damages cannot be collected if he can prove that he was where he should have been.

Throughout the United States, the invariable rule is to KEEP TO THE RIGHT; IN LONDON IT IS JUST THE OPPOSITE.

By Keeping Close to the Right-Hand Gutter, there is no uncertainty when a car comes the other way. (See Chart 169.)

In Passing a Slower Moving Vehicle going in the same way, swing out so that it is on the right, the passing car being on the left of the vehicle that is being passed.

The Rule That One Who Attempts to Pass Another on the Highway Going in the Same Direction has the right to do so in such manner as may be most convenient under the circumstances, and where damage results to the person passed, the former must answer for it, unless the latter, by his own carelessness, brought the disaster on himself, is applicable to one attempting to pass a standing vehicle when he approaches from the rear.

A Little Diplomacy and Good Nature under the above mentioned conditions is the motorist's greatest aid, and if every motorist could be advised to show the drivers of horse vehicles a little more courtesy and would heed the advice, it will not be long before these courtesies would bear fruit and you would find that these drivers will turn out or give a fair share of the road with more alacrity.

Go Slow at Turns in the Road, to have sufficient time to avoid the vehicle that may be coming toward you.

Go Slow at Cross Roads, for another car may be coming across at the same instant.

Take Bridges, Embankments and Narrow Roads at a Slow Pace, keeping the car under instant control.

Bridges in the Country Are Apt to Be Shaky, and it is dangerous to cross them at speed—beside being against the law.

Pull Up When the Horse Ahead Shows Signs of Fright, and if necessary stop the motor.

Raise the Right Hand When About to Make a Stop or Turn, as a warning to vehicles behind of your intention—and always regard the signal when it is made by the man in front. (See Chart 170.)

Another Signal That Is Coming Into Use Is the Raising of the Left Hand With Two Fingers Extended, as a warning to cars coming that they will find a police trap.

Do Not Follow a Car Too Closely, for it may stop without warning.

When a Car Comes Up From Behind, and shows signs of desiring to pass give it the road by swinging to the right.

Before Starting to Race It, remember that it is about the most dangerous thing that can be done, and that racing has caused almost all the automobile accidents.

Refer to chart 169 and note the various movements in passing and turning.

DRIVE SLOWLY

Through towns and villages. When passing schools and churches. On dusty or muddy roads when passing bicyclists or pedestrians. When an infirm or drunken man is in the road.

STOP

When There Is an Accident, whether it is your fault or not. Render all the assistance possible, and as a safeguard, get the names and addresses of witnesses.

When You See a Horse making a fool of himself.

REMEMBER

That a **Nervous Driver** may pull the wrong rein.

That a **Pedestrian** cannot make up his mind in a hurry when he wants to cross the road.

That Is Is Your Business to avoid danger, not the other man's.

That the Road is free for all, and that it pays to be courteous.

RAILWAY RATES FOR CONVEYANCE OF CARS.

A Car Will Only Be Received for Transport by freight either crated or set up.

The Usual Method in Shipping a car by freight is to ship it complete and run it right into the car, deflate the tires and see that the railroad company block the wheels so that the car will not pitch forward or backward.

It Is Also Well to See that car is braced from the side.

Get a Clear Bill of Lading from the railroad company so that you will have something to secure damages with in case of car being smashed.

It Is Well to Box the cushions and all loose parts separate.

The Charge for Conveyance must be ascertained of the railway company.

STORAGE OF GASOLINE.

The Insurance Companies, as well as the building commissioners, especially in large cities, have strict regulations regarding the storage of gasoline for a garage. See your local insurance company, who will furnish you with full data as to placing a gasoline storage tank for your garage.

HOW TO SELECT AN AUTOMOBILE.

POINTERS WHICH WILL AID BUYERS IN PICKING OUT SUITABLE CARS.

What Machine Is Needed for, and Where It Is to Go, as Well as Money for Purchase, Make Different Selections Proper.

WHAT TO PAY FOR A CAR.

What Is the car required for?

This is one of the first questions to be asked. For pleasure purpose only a standard type of body may be chosen, but for business uses the selection is more restricted, should any particular requirements in the matter of accommodation have to be met. That the country it is intended to be used in is a great consideration. Confined to any particular district, a car with a given gear and engine power may be advantageously adopted which would not give perhaps universal satisfaction. Thus in a flat district a low-powered car will do efficiently and infinitely more economically what in a hilly country would necessitate perhaps twice the power to do the work at all. Most cars will "climb any hill," for instance—yes, but some of them only at a very slow pace, which becomes too tedious in a really hilly country.

CONSTANT ATTENTION NECESSARY.

Whether you intend to keep a mechanician to look after your car, or whether you intend to look after it yourself, is another point to consider. There is a limit to the size of a car which the owner can, if it is in pretty constant use, attend to in all respects personally with success, unless he be a man of great leisure, and moreover, keen enough to put up with much of the drudgery involved. To obtain best results in running and the greatest economy in upkeep, it is useless to attempt to conceal the fact that constant attention must be paid to a car when it is at home, and where the average man can easily find time to do ample justice to a moderate-sized car, a large car might be too much for him in the amount of attention required.

WHAT TYPE OF BODY.

This is not much a matter of choice nowadays, as the cars are built in large quantities and to standard type, but it is possible to select a body suitable for the purpose you intend to use a car mostly. Putting aside for the moment the case of those who, from consideration of price alone, would confine themselves to a car of power and size suited for a two-seated body only, it is best to have a four-seater if only a small one. Though the back seats may be used only once in a while, they are nevertheless too often wanted if not there, and the advantages of being able to give friends a lift and of having plenty of room for luggage and parcels are well worth the slight difference in extra cost.

Should some form of optionally covered car be desired, then the cape hood arrangement is the simplest and most serviceable form of removable cover, and, in combination with a glass front or wind screen and suitable side curtains, will transform an open car in a very few minutes into a tolerably weather-proof vehicle. The coupe car is becoming very popular for all year 'round use, in the summer the top of coupe keeps the sun off, and, as the windows and front can be raised, the car is really cooler than an open car. In the winter this coupe can be closed and kept very comfortable. A closed car of this type also tends to keep the dust and dirt out, if the back is closed, and is becoming more popular, as the motorist is now looking for comfort more than speed.

When once the prospective customer has made up his mind to become an actual buyer, he should fix a price limit. With many people this fixes itself; that is to say, their means enable them to decide in very short time how far they can go. In any event, to arrive at a maximum figure is the first step toward that process of mental "weeding out" which has to be gone through when so many, and so great a variety of values are offered. Cars can be obtained at prices from $600 upward, and in all calculations a sum not less than, say $50 to $100 for a small car, and so on in proportion to size, will probably have to be laid out, in addition to the purchase price, in acquiring those accessories, spare tires and tubes, tools and lamps, which are necessary, and all of which are not always "thrown in" with the car. A good runabout, seating two can be had for $600 to $750, and as much as $6000 may be spent on a high-grade six-cylinder car.

Most cars at $600 and $700 have accommodations for only two, but quite often a rear rumble seat is included, so that three can be carried. The cheapest four-cylinder car, to carry four, would be about $900, and from this sum upward, an immense variety may be had. The popular price for cars to carry four passengers, and with four-cylinder engines, is $1500 to $1800.

The most luxurious and smooth-running of gasoline cars have, as a special refinement, six-cylindered engines, which are wonderfully silent and elastic, and enable the change speed gear to be almost dispensed with; but the cost of cars of this type renders such cars expensive, although I note that a very good car of six-cylinder type can now be had for $2500.

COST OF RUNNING—OR UP-KEEP.

Here lies the crux of the whole matter.

Closely allied with the important question of original outlay is that of running cost, which must be taken into calculation to a certain extent, when buying. The size of the bill for up-keep bears, of course, a direct proportion to the mileage done. As regards fuel consumption, the item will not be found a large one in any car up to, say, 20 horse-power, unless there is some radical defect in the system or temporary want of adjustment. In large and heavy cars the gasoline bill quickly mounts up.

The largest item in the cost of running is always that for tires, and this charge becomes heavier as the speed increases, and is, of course, again directly proportionate to the mileage run. It is not possible to give any general figures which would be of any use, but the statement may be made that no man, who can afford according to his means, a car up to, say, 20 horse-power, is likely to be frightened at the cost of up-keep unless he is very careless in his choice of a car, and, moreover, very unfortunate subsequently in the handling of it.

THE IGNITION SYSTEM.

There are three prominent methods for obtaining the electric spark, namely, by high-tension magneto machine, together with a coil and battery, the latter being used to start the motor, and after started the magneto supplies the current for ignition—this system is called "dual" system. Another system is a low-tension magneto, supplying current to a high-tension coil, thence to the spark plug. This system is also called a "dual" system when used in conjunction with a battery to start the engine on. The third system is called a "double" system of ignition, and consists of two independent systems of ignition, with two separate sets of spark plugs. This system is generally employed on large cars. Very few cars, even the cheapest, are unprovided with magneto ignition now.

TIRES.

The main feature to insist on about a car is the pneumatic tires. Insist on their being ample size and weight to support the car at high speeds. Small light tires spell constant punctures and troubles, not to mention short life. There is little to choose between the several makes of good tires available, and the manufacturers' lists give the maximum weight per wheel, which the various strengths and types are intended to carry, it being a good rule to keep well within the limits.

The disadvantage of fitting lighter tires to the front than to the rear wheels is that the convenience and benefit of interchangeability is lost. Some form of non-skid tire should be used for the rear—the Bailey, or some similar rubber, uneven tread is desirable, as this extra rubber costs but a very little additional amount, and the extra wear from the extra amount of rubber, to say nothing of the non-skid qualities, is worth the difference.

Solid tires are out of the question for vehicles traveling over eighteen miles per hour—we often see them on electric vehicles, and the owner feels quite well contented that he is saving money by putting the solid tires in place of the expensive pneumatic tires, but it will be only a short time before the vibration will jolt and jar the paste from the cells of the batteries, and new batteries are more expensive than pneumatic tires. The quick detachable demountable rim, and pneumatic tire is the most desirable of the lot, the tire is the same construction as usual (clincher), but the difference is in the rim. With the quick detachable rim, it simplifies the changing of a tire, but when you carry a quick detachable tire on a rim, which can be replaced on your wheel instead of the other rim, and with the tire already inflater, imagine the saving of time and labor.

Note.—See page 871, 'How to select a second-hand car."

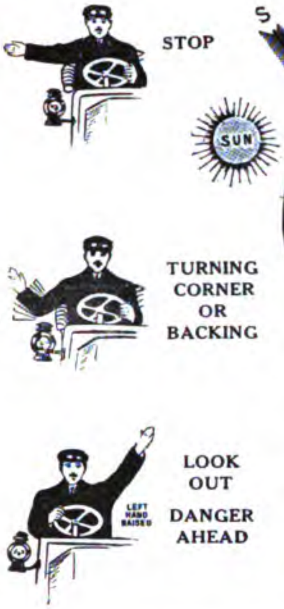


Fig. 1 - If you are driving in front of a car and must stop, slow down or turn a corner, signal to the party behind you as above, otherwise the car following might run into you.

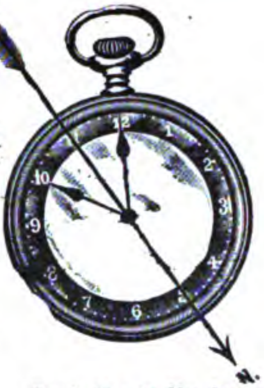


Fig. 2 How to Use Your Watch as a Compass, Sometimes Useful in Touring

Point the hour hand of your watch to the sun at any time of the day, and then lay the watch flat in the palm of your hand. A point midway between the hour hand and 12 on the dial will be due South.

SUPPLIES AND TOOLS FOR TOURING

When preparing for a tour, the supplies to be carried will depend on the country that will be covered, and the possibility of purchasing new parts along the route.

In any case, spare tires should be carried; at least one shoe and two tubes, and double this will render tire trouble less serious. See supplies in illustration below.

TOOLS

A large assortment of tools is shown on page 4 0—Here is a good selection:

Two monkey wrenches (large and small,) two screw drivers set of socket wrenches, pipe wrenches, two machinist hammers, cold chisel ([illegible] inch,) punch, copper bar (short and thick) to use between the hammer and work, cotter pin extractor, pliers, vise, knife files (assorted,) needles (assorted.) oil can, grease gun, emery cloth and sand paper.

TIRE MATERIAL

TIRE Repair outfit, tire tools, tire cement, extra lugs, two outer repair covers, two inner repair covers, ½ doz. inner valve parts, two extra inner tubes, two extra outer cases.

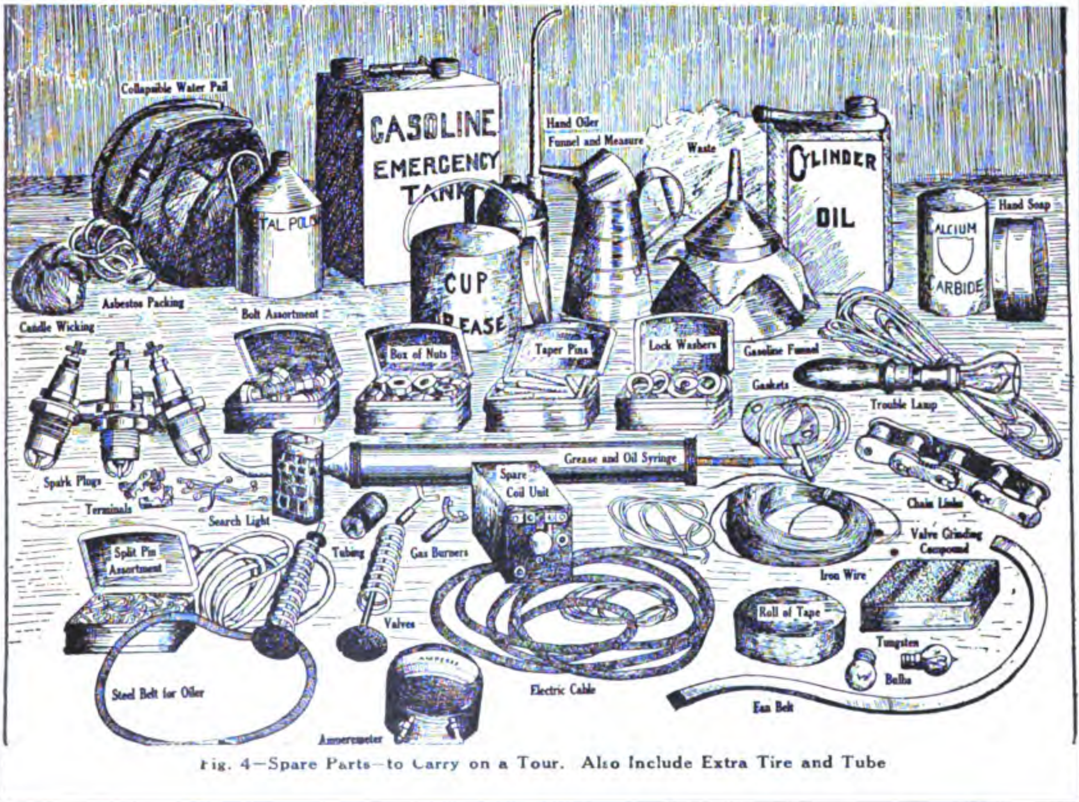


Fig. 4—Spare Parts—to Carry on a Tour. Also Include Extra Tire and Tube

CHART No. 170

AUTOMOBILE INSURANCE, ACCIDENT, LIFE AND INDEMNITY, WITH SAMPLE POLICY.

Summary of Provisions of Usual Policies Issued to Automobilists Covering Indemnity, Accident and Death.

We herewith give some of the principal provisions of the Automobile Liability Policy, which is believed to be typical of this class of insurance.

A property damage certificate also accompanies this policy, which indemnifies the assured against loss on account of injury to any one or destruction of other people's property resulting from an accident due to the ownership or use of an automobile.

A travelers' Automobile Liability Policy covers legal liability for damages for personal injuries caused by the ownership, maintenance or use of the automobile (while driven by any person not under sixteen years of age). Suits for damages may be the result of numberless mishaps, such as the unexpected acts of pedestrians, bicyclists, or children, who may dart in front of the car, skidding, collisions, the breaking of steering gear or the frightening of horses, which running away may injure or kill the occupants of the vehicle or others using the highways.

Under its policy the Company on receipt of notice of accident makes an investigation and in case of probable liability proceeds to make a settlement at its expense without litigation. Should a suit for damages follow, the Company defends the action, defrays all court costs and expenses, and pays within the limits of the policy any damages that may be awarded.

Policies are usually written for limits of $5,000 for injuries or death of one person. $10,000 for one accident causing injuries or death of more than one person.

These limits may be increased if desired, and the policy does not lapse when these limits have been expended, but continues the undertaking to pay within such limits upon every other accident that may occur while the policy is in force.

SAMPLE AUTOMOBILE POLICY.

The Travelers' Insurance Company, of Hartford, Connecticut.

(Herein called the Company) Does hereby agree with the assured, named and described as such in the declarations forming part hereof, as respects bodily injuries accidentally sustained, including death at any time resulting therefrom as follows:

Indemnity for Loss.

I. To Indemnify the Assured against loss by reason of the liability imposed upon him by law for damages on account of such injuries.

Service.

II. To Serve the Assured upon notice of such injuries by such investigation thereof, or by such negotiation or settlement of any resulting claims as may be deemed expedient by the Company.

Defense.

III. To Defend in the name and on behalf of the Assured any suits which may at any time be brought against him on account of such injuries, including suits alleging such injuries and demanding damages therefor although such suits, allegations or demands are wholly groundless, false or fraudulent.

Expenses.

IV. To pay all costs taxed against the assured in any legal proceeding defended by the Company, all interest accruing after entry of judgment upon such part thereof as shall not be in excess of the limits of the Company's liability as hereinafter expressed, all expenses incurred by the Company for investigation, negotiation or defense, and the expense incurred by the assured for such immediate surgical relief as shall be imperative at the time any such injury is sustained.

Persons Covered.

V. This agreement shall apply to such injuries sustained by any person or persons.

Operations Covered.

VI. This agreement shall apply only to such injuries so sustained by reason of the ownership or maintenance of any of the automobiles enumerated and described in said declarations and the use of such automobiles for the purposes specified in item 3 thereof. If such specified use is for private or pleasure purposes it shall include ordinary business purposes except the carriage of passengers for a consideration, express or implied, or demonstrating or testing, or the transportation or delivery of material or merchandise. If such specified use is as a commercial vehicle (meaning thereby an automobile used for transportation and delivery of material or merchandise) it shall include the loading and unloading of goods carried on any such automobile. This agreement shall not apply while any such automobile is driven or manipulated in any race or competitive speed test, or by any person under the age of sixteen years.

Location Covered.

VII. This agreement shall apply only to such injuries so sustained while within the limits of the United States of America or the Dominion of Canada.

Policy Period.

VIII. This agreement shall apply only to such injuries so sustained by reason of accidents occuring within the policy period as limited and defined in item 2 of said declarations.

Limits of Indemnity.

IX. The Company's liability for the Indemnity provided in Paragraph 1, foregoing for an accident resulting in such injuries so sustained is limited to the amounts and as expressed in item 4 of said Declarations, which limits shall apply to each automobile covered hereby.

CONDITIONS.

Premium, Computation, Cancellation.

The premium includes a charge for each automobile dependent upon its description and the purposes for which it is to be used.

This policy may be cancelled at any time by either of the parties upon written notice to the other party stating when thereafter cancellation shall be effective, and the date of cancellation shall then be the end of the policy period. If such cancellation is at the Company's request the earned premium shall be computed and adjusted pro rata. If such cancellation is at the Assured's request, the earned premium shall be computed and adjusted at short rates in accordance with the table printed hereon. Notice of cancellation mailed to the address of the Assured herein given shall be a sufficient notice and the check of the company, similarly mailed, a sufficient tender of any unearned premium.

Inspection.

The Company shall be permitted, at all reasonable times during the policy period, to inspect any of the automobiles covered by this policy.

Notice.

The Assured, upon the occurrence of an accident, shall give immediate written notice thereof to the Company, or to its duly authorized agent, with the fullest information obtainable. He shall give like notice with full particulars of any claim made on account of such accident. If, thereafter, any suit is brought against the Assured, he shall immediately forward to the Company every summons or other process served upon him. The Assured, when requested by the company shall aid in effecting settlements, securing evidence, the attendance of witnesses and in prosecuting appeals. The Assured shall not voluntarily assume any liability, settle any claim or incur any expense, except at his own cost, or interfere in any negotiation for settlement or legal proceeding without the consent of the Company previously given in writing.

Recovery.

No action shall lie against the Company to recover for any loss under Paragraph I, foregoing, unless it shall be brought by the Assured for loss actually sustained and paid by him in money in satisfaction of a judgment after trial of the issue, and no such action shall lie to recover under any other agreement of the Company herein contained unless brought by the Assured himself to recover money actually expended by him. In no event shall any such action lie unless brought within ninety days after the right of action accrues as herein provided.

Special Statutes.

If the limitation of time for notice of accident or for any legal proceeding herein contained is at variance with any specific statutory provision in relation thereto, in force in the state in which the business operations herein described are conducted, such specific statutory provision shall supersede any such condition in this contract inconsistent therewith.

Assignment.

No assignment of interest under this policy shall bind the Company unless the consent of the Company shall be endorsed hereon.

Co-Insurance.

If the Assured carries a policy of any other insurer covering concurrently a claim covered by this policy, he shall not recover from the Company a larger proportion of any such claim than the sum hereby insured bears to the whole amount of such concurrent insurance.

Subrogation.

The Company shall be subrogated in case of any payment under this policy, to the extent of such payment, to all the Assured's rights of recovery therefore against persons, corporations, or estates.

Changes.

No condition or provision of this policy shall be waived or altered except by endorsement attached hereto signed by the president, a vice-president, secretary, or assistant secretary of the Company; nor shall notice of any agent, nor shall knowledge possessed by any agent or by any other person be held to effect a waiver or change in any part of this contract. The personal pronoun herein used to refer to the Assured shall apply regardless of number or gender.

Declarations.

The statements in items numbered one to seven inclusive, in the Declarations hereinafter contained, are warranted by the Assured to be true except such as are declared to be matters of estimate only. This policy is issued in consideration of such warranties, the provisions of the policy respecting its premium and the payment of the premium in such Declarations expressed.

In the Declarations are included items as follows: Item 1. Name, address, occupation, etc., of Assured. Item 2. Period of the policy. Item 3. Description of car or cars and statements as to the kind of use made of them, for pleasure, commercial, etc. Item 4. Limits of the Company's liability. Item 5. Method of garaging cars. Item 6. No personal injury has ever been caused by any automobile driven by or for me—except as herein stated. Item 7. No similar insurance has been declined or cancelled by any company during the past three years—except as herein stated.

INSTRUCTION No. 37

Digest of the Automobile Laws of Various States and Canada Revised to July 1, 1911

We here present for your convenience a brief outline of the automobile laws of several states. While every effort has been made to give authentic and latest information the legislation is constantly changing and cannot guarantee the accuracy of this summary.

Alabama.

Registration.—With the Secretary of State; fee, $7.50 under 20 h. p., 20 to 29 h. p., $12.50; 30 to 39 h. p., $17.50; over 40 h. p., $20; electric vehicles, $12.50; steam vehicles, $15; motorcycles, $3; commercial cars, $25; manufacturers' and dealers', $100. Fiscal year begins October 1st. Distinctive number plate to be displayed front and rear, color changed annually. Chauffeur's license, $5. Equipment required is, brake, muffler and a non-odoriferous appliance. Must display during hours of darkness, two lighted lamps on front, and one on rear to shine on number plate.

Speed.—Reasonable and proper, having regard to local conditions. Not over 30 m. p. h.

Non-Residents.—Reciprocal exemption.

Arizona.

Regulations local, no state law.

Arkansas.

Registration.—With the Secretary of State, at Little Rock, annually; fee $5. Dealers must register one car of each class in which they deal, cars being classified as electric, steam, or gasoline. Transfer fee in case of purchase of registered car, fifty cents. Chauffeurs must register annually, fee $1. Badges must be worn while operating, number plates having letters "ARK" at least one inch in height, and the registration number in Arabic numerals at least four inches high, a stroke one-half inch in black on a white ground, must be carried in front and rear. Lamps must be carried as follows: Two white lights, visible at least 200 feet, must be carried in front, with the registration number in letters at least one inch in height attached to the glass; at the rear, one red light, visible from the rear and also illuminating the license number, must be carried.

Speeds.—In business section, 15 m. p. h.; residence section, 20 m. p. h.; while rounding or approaching corners or dangerous crossings, 6 m. p. h.

Non-residents.—License tags of home state must be carried.

California.

Registration.—With Secretary of State; fee, $2; manufacturers and dealers allowed to register one car of each style and duplicate seals for others costs 50 cents; good for 5 days after sale of car; chauffeurs' license, $2; when operating must wear badge furnished by Secretary of State; circular metal seal displayed on car and return to Secretary of State on sale of car; tag displayed on rear; numerals 3 inches high, strokes ½ inches wide, and abbreviated name of state 1 inch high, characters to be black on white background; two white lights forward showing numerals in figures 1 inch high and red light reverse from one hour after sunset to one hour before sunrise; must be equipped with brakes and sound signal on approaching pedestrian or person in charge of a horse.

Speed.—Always reasonable, in built-up sections 10 m. p. h., 15 miles elsewhere in municipalities; outside, 20 m. p. h.; on approaching bridge, dam, sharp curve or steep descent, stop car on signal from driver of horses, and stop engine on request.

Non-Residents.—Reciprocal exemption if tag of state of residence is displayed on rear.

COLORADO.

No state law, regulation local.

CONNECTICUT.

Registration.—Renewed annually by Secretary of State at Hartford; fee for each certificate; 50 cents per h. p. for cars under 25 h. p., and 60 cents per h. p. for cars over 25 h. p.; motorcycles, $1; commercial cars $5; manufacturers, $1 per car being tested or demonstrated; dealers, $20 for all cars; operator's licenses, for persons 18 years old or over, $2, must be renewed yearly, carried while operating and may be revoked at any time by the Secretary of State; number tags to be carried stationary, front and rear, numerals 4 inches high, strokes ½-inch wide, not over two tags to be displayed on either front or rear; on motorcycles, initial letters of state and numerals at least 1 inch high painted or displayed on tag; at least one light forwards, visible 200 feet, and red light on rear so arranged as to throw white light upon rear number tag, from one hour after sunset to one hour before sunrise; must be supplied with serviceable brakes and signal device which must be sounded when approaching sharp turn, bridge, curve or steep descent; motorcycle not be operated with open muffler.

Speeds.—Careful and reasonable at all times; 25 m. p. h. for distance of ⅛ mile sufficient evidence of violation of speed provision; speed to be reduced upon approaching or passing pedestrian, horse, highway crossing, bridge, sharp curve or steep descent; must stop both car and engine on signal from teamster.

Non-Residents.—Exempt for not over ten successive days at any one time; exemption revoked upon being convicted of violating laws.

DELAWARE.

Registration.—Annual with Secretary of State at Dover; fee $5; motorcycles, $3; operator's fee $5, minimum age of operator, 16 years; transfer of license on sale of machine, $1; dealers license fee, $5; tags must be carried on front and rear of autos, and on either side of motorcycles; dealers supply own tags with numerals 5 inches high and words "Delaware Dealer;" rear tag illuminated and at least one white light forward and red light in rear from one hour after sunset to one hour before sunrise; cars must be equipped with brakes and signal device; tire chains prohibited except on highways of natural dirt, plank, asphalt, brick, belgium block or one inch of ice or hardened snow, unless necessary for safety.

Speeds.—Always reasonable, 12 m. p. h., where buildings are less than one hundred feet apart; 6 m. p. h. at curves and intersections, and 20 m. p. h. in open country, reduced to 12 at curves, intersections, steep descents and when passing other vehicles; cars must stop on signal or request from person in charge of horse.

Non-Residents. — Reciprocal exemption privileges.

DISTRICT OF COLUMBIA.

Registration.—With Secretary of Automobile Board, fee $2 for each tag; applicant must be over 18 years of age (exceptions) and must qualify before Board of Examiners, no fee; unlicensed persons may operate if accompanied by licensed chauffeur; temporary permits issued pending examination; tags must have letters at least 3 inches high and the initials "D C.," to be carried on rear of machine; two lamps front and one red tail lamp carried on left side of car and throwing white light on license tag; cars must be equipped with signal and locking devices. No loud or discordant signals permitted.

Speeds.—Within fire limits, 12 m. p. h.; in parks 15 m. p. h.; 8 m. p. h. at street intersections; 6 m. p. h. around corners; 4 m. p. h. on certain specified streets; outside of fire limits 20 m. p. h.; 12 m. p. h. when meeting or passing other vehicles; must stop machine on signal from driver of horse; must not drive closer together than 15 feet.

Non-Residents.—Reciprocal exemption for transient tourists, provided resident state tag is displayed; other non-residents are exempted for 60 days upon registering with Secretary of Automobile Board within 24 hours after arrival.

FLORIDA.

Registration.—With Secretary of State, giving description of car, fee $2; no time limit; registration transferable on sale of the machine, fee $2; operator's license fee, $2; tags to have numerals at least three inches high and two inches wide, to be displayed on the rear of car; two lamps between sunset and sunrise; signal must be sounded on approaching pedestrian or person in charge of horse.

Speeds.—At sharp curves, bridges, fills and intersections, 4 m. p. h; at all other times speed to be reasonable and machines to be under perfect control; must stop machine on signal from person driving horse and stop engine, if so requested; speed limits may be set aside by County Commissioners for speed contests or races.

Non-Residents.—Exempt for 30 days.

GEORGIA.

Register with Secretary of State at Atlanta; fee, $2.

Chauffeurs are not required to register.

The state furnishes the tags.

Speed limits: A reasonable rate of speed is permitted, no limits being named except that at bridges, curves and crossings the car must not exceed 6 miles per hour.

Lights: At least one white light in front and a red light in the rear, illuminating number.

IDAHO.

No state law, regulations local.

ILLINOIS.

New law in effect July 1, 1911. Write Secretary State, Springfield, Ill., for copy.

Register.—With Secretary of State, Springfield, Ill.

Annual Registration required.

Registration fees for owners:

25 horse power or less	$ 4.00
35 horse power or more than 25	6.00
50 horse power or more than 35	8.00
More than 50	10.00
Electric vehicles	5.00
Motorcycles	2.00

Tags (2).—Furnished by the state, to be displayed on front and back; duplicates can be had for 50 cents, if lost.

Non-Residents.—No license required dura temporary sojourn.

In Case of Sale.—Number plates must be removed before delivering car and seller must apply for new license within 10 days. Send statement to Secretary of State showing date of sale, etc., together with his registration number and name and $1.

Purchaser must secure new license within 10 days.

Manufacturers and Dealers.—Fee is $15 annually.

Tags.—Different from private plates. Duplicate can be had for $1. Which must be placed on all cars.

Chauffeurs.—Fee is $5 annually. Application must be accompanied with photo. Must pass examination. No one under 18 can secure a chauffeur's license.

Chauffeur's badges supplied by state.

INDIANA.

Registration.—With Secretary of State at Indianapolis; fee, $1; no time limit and non-transferable; manufacturers and dealers must register one machine of each style or type, duplicate seals 50 cents each; tags to have white numerals on black ground at least 4 inches high and ½ inch wide; also state initials; numbers to be displayed front and rear; must also display circular metal seal furnished by Secretary of State; registration expires on sale of machine but, same number may be re-assigned to new machine; lamps to be carried after dark; car must be equipped with brake and signal which must be sounded on approaching person with horse; provisions as to numbers do not apply to motorcycles.

Speeds.—In closely built-up portions, 8 m. p. h.; 15 m. p. h. in other portions of municipalities; 20 m. p. h. in open country; on approaching and traversing bridge, intersection of highways, sharp curve or steep descent, speeds must be reasonable and vehicle under control; 6 m. p. h. while passing horse or other draught or farm animal; rates of speed not to be diminished by any local ordinances.

Non-Residents.—Exempt if tag and initial of state of residence is displayed.

IOWA.

Registration.—With Secretary of State, at Des Moines; fee, $8 up to 20 h. p.; 40 cents for each additional h. p. over 20. Electric and steam vehicles, $15; motorcycles, $3; dealers, $15. License fee takes place of tax; expires on sale of car; seal furnished by Secretary of State must be displayed on car and no other number; owner must furnish tag to be displayed on rear having number 3 inches high and letters "IA" 2 inches high, ½ inch strokes; at least one lamp forward and red light on rear between one hour after sunset and one hour before sunrise; cars to be equipped with brakes and signal device.

Speeds.—Must always be reasonable; 10 m. p. h. in built-up portions; 15 m. p. h. in all other portions of municipalities and 20 m. p. h. in open country; speed must be reduced when approaching intersections of highways, bridges, sharp curves or steep descents. Felony to not stop after an accident and give name and address. Overtaken vehicles always have right of way.

Non-Residents.—Exempt providing home regulations are complied with.

KANSAS.

Registration.—Not required by state; necessary in some localities; state law provides for one or more lamps between one hour after sunset and one hour before sunrise.

Speeds.—In thickly settled districts, 10 m. p. h.; elsewhere 20 m. p. h.; speed must always be reasonable and be reduced at crossings.

KENTUCKY.

Registration.—With Secretary of State at Frankfort; annual fee, $5 for less than 25 h. p., $10 for 25 to 49 h. p., and $20 for 50 h. p. and over; expires ten days after sale of machine, seal furnished to be affixed to car; applies to manufacturers' machines kept for private use or for hire; manufacturers and dealers must register one car of each class, and number all of that class the same; number plates to have figures, 4 inches high with strokes ½ inch in width and the letters, "KY" 1 inch high, all to be of white on a black background; numbers to be displayed on front and back and also on front lamps of which there shall be two, in characters, 1 inch high; lamps to be visible at least two hundred feet and to be lighted between sunset and one hour before sunrise; red lamp to be displayed on rear: car to be equipped with efficient brakes, also suitable signal device; engine not be left running when car is without attendant.

Speeds.—Always reasonable; 10 miles per hour in thickly settled districts, 8 miles per hour at crossings, 15 miles per hour in residence section and 20 miles an hour in open country shall be considered unreasonable; shall come to full stop to allow frightened draft animals to pass.

Non-Residents.—Exempt from registration if law of home state is complied with.

LOUISIANA.

Regulation local, no state law.

MAINE.

Registration.—With Secretary of State at Augusta, fee $2; no time limit; registration expires on sale of machine; operator's registration fee $2; manufacturer's or dealer's license fee, $10; good for 5 days after sale of machine; driver need not be licensed if accompanied by licensed operator; two tags, furnished by Secretary of State, having number 4 inches high and the word "Maine" 1 inch high, must be carried on the front and rear; number on the rear of motorcycles is all that is required; one lighted lamp must be carried between one hour after sunset and one hour before sunrise; cars must be equipped with a regular device which can be heard 300 feet.

Speeds.—Always reasonable; 8 m. p. h. in cities, towns, etc.; unless local ordinance permits a higher speed; 15 m. p. h. in open country; must stop on signal from driver of horse; special restrictions are made applying to certain specified towns, use of automobile prohibited in town of Eden, Mount Desert, Tremont and Southwest Harbor, if act accepted by said towns.

Non-Residents.—Exempt if local authorities permit; must carry home state tags, front and rear.

MARYLAND.

Registration.—Annually with Commissioner of Motor Vehicles, at Baltimore, by affidavit describing machine and stating that owner is competent to drive a car, fee $6, under 20 h. p.; $12, for 20 to 40 h. p., and $18 for over 40 h. p.; trucks, $3; $1.80 for motorcycles; does not apply to manufacturers, except as to machines kept for private use or for hire; dealer's general distinguishing mark $24; motorcycle dealer $10; operator's license, $2, no time limit; 16 years age limit; motorcycle operator's license, $1, 14 years age limit, no license required if accompanied by licensed driver; numbers issued by Commissioner of Motor Vehicles; 5 inches high, ½ inch stroke, on a contrasting background, must be displayed on front and rear; numbers may be used for 5 days after sale, with written consent of former owner; two lamps throwing light at least 200 feet, with number at least 2 inches high on face and one red light showing from rear must be carried between 1 hour after sunset and 1 hour before sunrise; car must be equipped with efficient brakes and signal device which must be sounded every 200 feet at night if lights fail to operate; must sound signal on approaching pedestrian or horse, also on approaching sharp curves, highway intersections and tops of hills in open country; signal must not be sounded while passing horse.

Speeds.—Always reasonable; 12 m. p. h. at intersections of main highways in open country, in built-up portion of municipalities, at sharp curves and where lights fail to operate at night, except in cities of 16,000 or more inhabitants; 18 m. p. h. in not thickly settled districts; 25 m. p. h. in open country; 6 m. p. h. on approaching horse or other animal, car must be stopped if animal appears to be frightened; speed regulations may temporarily be set aside by the local authorities for the purpose of holding speed contests or races on highways.

Non-Residents.—Residents of New York, Pennsylvania, Delaware, Virginia, and West Virginia exempt if tags of home state are displayed; residents of other state exempt for two periods of 7 consecutive days; each must display tags and marker furnished by Commissioner of Motor Vehicles. The Governor has authority to make reciprocal agreements.

MASSACHUSETTS.

Registration.—With State Highway Commission at Boston; annual fee; commercial autos $5; motorcycles $2; pleasure cars, under 20 h. p., $5; 20 to 30 h. p., $10; 30 to 40 h. p., $15; 40 to 50 h. p. $20; over 50 h. p. $25; expires on sale of machine, operator's license, $2; professional chauffeur's license, $2; renewal 50 cents annually; manufacturers' and dealers' registration fee $25 for 5 or under; $5 for each one in excess of that number; motorcycle dealer's license $10; certificate must be carried in car; operator's license must always be carried; re-assigning old number to new auto $2; to motorcycle $1; person operating car need not have license if accompanied by licensed operator; number plates furnished by Commission for automobiles and seals for motorcycles; two white lights forward throwing light 200 feet from 1 hour after sunset to 1 hour before sunrise; car must have brake, signal device, muffler and locking device.

Speeds.—Always reasonable; 20 m. p. h. in open country; 15 m. p. h. in suburbs and 8 m. p. h going around curves or approaching and traversing intersections or in thickly settled district shall be considered unreasonable.

Requirements for 10 days providing tag of home state is carried, 3 months registration half regular fees.

Non-Residents.—Exempt from registration

MICHIGAN.

Registration.—With Secretary of State, at Lansing; annually; fee $3; registration expires on sale of car or may be re-assigned on payment of $1; manufacturers' and dealers' license fee, $10; number plates, $2 per set; chauffeur's license, $2; badge furnished by Secretary of State must be worn while operating; owner of car must obtain from Secretary of State and carry on front and rear, tags showing number in figures 3 inches high with stroke ½ inch wide and state initial 1 inch high in white and black; only one registration number to be shown on rear; two white lights on front and one red light on rear must be carried from 1 hour after sunset to 1 hour before sunrise.

Speeds.—Always reasonable; in municipalities, 15 m. p. h. and 4 m. p. h. in business sections; in open country, 25 m. p. h.; 10 m. p. h. when approaching pedestrian or horse; on signal from driver of any draught animal, machine and engine must be brought to a stop.

Non-Residents.—Reciprocal exemption provided tag of home state is displayed on both front and rear.

MINNESOTA.

Registration.—With Secretary of State, at St. Paul; renewed every 3 years, fee $1.50; dealers' or manufacturers' registration $10, duplicate renewals $1; chauffeur's license $3; when operating, chauffeur must wear the badge furnished by Secretary of State; tag furnished by Secretary of State must be carried on rear; two white lights forward, and red light in rear, throwing white light on rear number tag must be carried 1 hour after sunset to 1 hour before sunrise; cars must be equipped with brakes and signal device, and gasoline cars must use muffler within city or township limits.

Speeds.—Must always be reasonable; when approaching or traversing bridge, dam, sharp curve or steep descent, speed in cities and villages, 10 m. p. h.; 25 m. p. h. in open country; on request of driver of horse, operator must stop car, and when necessary, stop engine; joy riding is made illegal.

Non-Residents.—Thirty days' exemption if home state tag is carried. In effect January 1, 1912.

MISSISSIPPI.

Regulation local, no state law.

MISSOURI.

Registration.—With Secretary of State, at Jefferson City, Mo.; annual fee; under 12 h. p., $2; 12 to 24 h. p., $3; 25 to 35 h. p., $5; 36 to 47 h. p., $7; 48 to 59 h. p., $8; 60 to 71 h. p., $10; 72 h. p. and over, $12; applications made after August 1 will be subject to 50 per cent. of fee only; seal issued by Secretary of State must be attached to car; registration expires on sale of car by private owner; chauffeur's license issued to persons over 18 years of age on payment of

$1.50; badge must be worn while operating; manufacturers' license fee $16; four duplicates free and others at $5 each; two front lights, lighted ½ hour after sunset to 1 hour before sunrise visible 200 ft.; red light in rear; must display state number plate in front and rear; only one state tag to be shown at once; cars must be equipped with brakes and signal devices.

Speeds.—Reasonable; not over 25 m. p. h. in open country.

Non-Residents.—Twenty days' exemption, provided home state tag is displayed.

MONTANA.

No state law; regulations local.

NEBRASKA.

Registration.—Annual with Secretary of State, at Lincoln; fee $1; expires on sale of car; application for new registration must be accompanied by certified bill of sale; metal seal must be carried on car; numerals 3 inches high, on rear of car, with letters "NEB." not less than 2 inches high; one lamp forward and one red lamp reverse between 1 hour after sunset and 1 hour before sunrise.

Speeds.—Always reasonable; 10 m. p. h. in built-up portions; in other portions of cities, towns, etc., 15 m. p. h.; in open country 20 m. p. h.; operator must stop car on signal from driver of any draught animal.

Non-Residents.—Exempt, providing tag of home state is displayed.

NEVADA.

Persons hiring automobiles must secure license and pay fee of $2.50 per month.

NEW HAMPSHIRE.

Registration.—With Secretary of State, at Concord; fee, under 15 h. p., $10; 15 to 30 h. p., $15; 30 to 40 h. p., $20; 40 to 50 h. p., $25; 50 to 60 h. p., $30; over 60 h. p., $40; certificate must always be carried in car; expires on sale of machine; collective registration of cars by manufacturers or dealers allowed; fee, $40; motorcycle registration fee, $2; fee for number tags, $1 per pair; private operator's annual license, $1; professional chauffeur's license, $5 annually; commercial vehicle, $10; unlicensed person may drive if accompanied by licensed operator; tags must have numerals 4 inches high, followed by letters "N. H."; carried both front and rear; motorcycles need carry only one tag; two lamps, having number 1 inch high on face, must be carried between 1 hour after sunset and 1 hour before sunrise; car must be equipped with brake, muffler and signal device; muffler must be used in built-up portions of towns; signal must be sounded at intersections and curves.

Speeds.—10 m. p. h. in business districts of towns; elsewhere 25 m. p. h.; must be reduced at crossings, curves, descents and bridges; must stop car on signal from person in charge of horse.

Non-Residents.—Exemption for 10 days if law of home state is complied with and tag displayed.

NEW JERSEY.

Registration.—With Commissioner of Motor Vehicles, at Trenton, or any of the agencies appointed by the Commissioner, some of which are located in New York City and Philadelphia. All licenses expire December 31 of each year. Annual; fee, 1 to 10 h. p., $3; 11 to 29 h. p., $5; 30 h. p. or over, $10; fee for transfer, $1; motorcycles, $2 annually; manufacturer's and dealer's fee, $5 per car; operator's license, issued after examination, less than 30 h. p., $2 annually; 30 h. p. or over, $4; certificate must be carried when operating; numbers, on both front and rear, must be 4 inches high and have stroke ½ inch wide; numbers on motorcycles such as Commissioner may prescribe; two white lights forward, visible 250 feet, and one red light reverse must be carried from 30 minutes after sunset to 30 minutes before sunrise; motorcycles, one white light, visible 200 feet forward between 1 hour after sunset and 1 hour before sunrise; autos must have efficient brake and if over 10 h. p., two brakes, one of them foot operated; motorcycle must have one brake, hand or foot operated.

Speeds.—8 4-7 m. p. h. on curves; 15 m. p. h. at intersections; 12 m. p. h. in built-up portions of towns and cities; 15 m. p. h. within 200 feet of horses, etc.; 25 m. p. h. in open country.

Non-Residents.—Must take out yearly license same as resident. No reciprocal exemption.

NEW MEXICO.

No territorial law; regulations local.

NEW YORK.

Registration.—With Secretary of State, at Albany; seal must be displayed on car; fee, 25 h. p. or under, $5; 25 to 35 h. p., $10; 35 to 50 h. p., $15; over 50 h. p., $25; commercial cars, $5; seal to be returned within 10 days after sale of car, except in the case of the vendor being a manufacturer or dealer; manufacturers and dealers required to register one car of each type, fee $15; duplicate number plates $1 each; chauffeur's fee, $5; must wear badge while driving; tag 6 inches wide and 15 inches long, to be displayed in front and rear, so fastened as not to swing; two lamps forward, having number on face 1 inch high and one red lamp reverse; cars must be equipped with brakes and signal device; joy riding prohibited.

Speeds.—Always reasonable; over 30 m. p. h. shall be considered unreasonable; local authorities may lower rate to 15 m. p. h.; signal must be sounded before every cross-road or street and upon approaching pedestrians in the highway and upon turning curves.

Non-Residents.—Reciprocal exemption for 10 days.

NORTH CAROLINA.

Registration.—With Secretary of State, at Raleigh; annually on first of July; fee, $5; renewals $1; certificate must be returned within 10 days, of sale of car; fee for transfer of number, $1; seal must be displayed on car; tags must be carried on front and rear, have black numeral 3 inches high; strokes ½ inch wide; state initials 1 inch high, on white ground; two white lights forward and one red light reverse, between 1 hour after sunset and 1 hour before sunrise; reasonable warning must be given to driver of horse.

Speed.—Always reasonable; 8 m. p. h. in business portions and 12 m. p. h. in other sections of town and cities; 25 m. p. h. in open country; 5 m. p. h. when approaching or traversing intersections, curves, steep descents, bridges and dams; 8 m. p. h. when near draught animals; must stop car and engine on request of driver of frightened horse and male occupants over 15 years old must render necessary aid; local authorities may reduce speed limits but must post signs stating rate permissible.

Non-Residents.—Temporarily exempt.

NORTH DAKOTA.

Registration.—With Secretary of State at Bismarck; annually; fee $4; two lights in front; motorcycles to carry one light; must sound signal when overtaking draught animals; must use muffler when on streets of villages, towns or cities and when passing horse-drawn vehicles.

Speed.—Speed to be reasonable at all times, having regard to local conditions; not over 30 m. p. h. at any time; 10 m. p. h. in incorporated municipalities.

Non-Residents.—Exempt if temporarily in state, provided home state tag is displayed.

OHIO.

Registration.—Annual, at Columbus; before January 1; with Secretary of State; fee, for gasoline or steam cars, $5; for electric cars, $3; manufacturers' or dealers' fee, $10 annually for each make, determined by motive power; $2 for each duplicate, including tags; chauffeur's fee, $2 annually; badge must be worn while operating; tags must be carried front and rear; cars must be equipped with brakes and signal device; must carry two white lights forward and red light reverse, throwing white light on rear number, from 30 minutes after sunset to 30 minutes before sunrise.

Speeds.—Always reasonable; 8m. p. h. in built-up portions of municipalities; 15 m. p. h. in other portions thereof; 20 m. p. h. in open country; rates not to be diminished by local authorities; must reduce speed when approaching horse or other draught animal and must stop on signal; owner's written consent must be in possession of person operating car in his absence.

Non-Residents.—Reciprocal exemption, if law of home state is complied with.

OKLAHOMA.

Regulations local, no state law.

OREGON.

Registration.—With Secretary of State at Salem; fee, under 26 h. p., $3; 27to 36 h. p., $5; 37 to 40 h. p., $7.50 over 40 h. p., $10; chauffeur's license, $2; number plates different color each year; state abbreviation in letters one above the other; number 3 inches long with ½in. stroke, 3 inches high, shown on rear in light color; one light showing white forward, visible 200 feet, and red reverse; number on white lamps forward; cars must have brakes and use mufflers in city limits; chauffeurs must wear badge when driving.

Speed.—8 m. p. h. in built-up portions of villages or cities; 8 m. p. h. when within 100 yards of a horse; in open country, 25 m. p. h.; 4 m. p. h. at crossings; car must reduce speed on observing frightened horse and stop on request.

Non-Residents.—Exempt for 30 days if laws of home state are complied with and tag is displayed.

PENNSYLVANIA.

Registration.—With State Highway Department at Harrisburg; annually; fee, under 20 h. p., $5; 20-50 h. p. $10; over 50 h. p., $15; motorcycles, $2: professional operator's license, $2; must carry license and wear badge outside when operating; to operate when under 18 years old a special license is necessary; registration expires on sale of machine; may be re-assigned to vendor, on payment of $1 fee; dealer's registration, $5; tags to be carried on front and rear; motorcycles must have 3-inch numbers attached to or painted on rear mud guard; rear number on cars to be illuminated by white light from red tail lamp and two white lights visible 200 feet, must be carried forward between 1 hour after sunset and 1 hour before sunrise; one light forward on motorcycle; use of cut-outs prohibited when passing vehicle.

Speed.—Reasonable, and not over 24 m. p. h.; must not overtake street car on side where passengers are being discharged.

Non-Residents.—Reciprocal 10 day exemption, provided tag of home state is displayed.

RHODE ISLAND.

Registration.—With Board of Public Roads, at Providence, expires within a year or on sale of car; fee, 20 h. p. or less, $5; 20 to 30 h. p., $10; 30 to 40 h. p., $15; over 40 h. p., $25; motor truck, $2; mortorcycle, $1; dealers' fee, $50; operator's license, good for year, $1; motorcycle, $1; certificate of registration must be carried in car, and license when operating; person driving need not be licensed if accompanied by licensed operator; tags having numbers and state initials 4 inches high, front and rear; motorcycle number either painted on, or tag 1 inch high; one white light forward and one red light reverse throwing white light on rear numbers, from 1 hour after sunset to 1 hour before sunrise; cars must have brake, muffler, signal and also a locking device which must be used when car is left unattended; motorcycle not to be operated with cut-out open; tire chains may be used on macadamized roads only when necessary for safety.

Speeds.—Always reasonable; 15 m. p. h. in built-up portions; 25 m. p. h. in open country; racing prohibited; must stop on signal from driver of horse.

Non-Residents.—Ten day exemption per year, providing home state laws are complied with and tag displayed; conviction for violating regulations revokes license.

SOUTH CAROLINA.

Registration.—With Clerk of County Court of various counties; within 10 days after acquisition of machine; fee, $1; dealers and manufacturers exempt except as to machines kept for private use or hire; number and county name on rear of car; black characters, 3 inches high, stroke ½ inch wide, on white ground carried on rear; at night and in fog must carry white light forward and red light reverse.

Speeds.—Always reasonable; 15 m. p. h. limit and 6 m. p. h. at highway intersections, bridges, curves and steep descents.

Non-Residents.—No state provision.

SOUTH DAKOTA.

Registration.—With Secretary of State; fee, $1; no time limit; expires on sale of machine, but old number may be re-assigned to vendor; seal furnished must be displayed on car; number on rear 3 inches high, also letters "S. D." 2 inches high, one light forward and red light reverse, showing number 1 inch high, between 1 hour after sunset and 1 hour before sunrise.

Speeds.—Always reasonable; 10 m. p. h. in built-up portions of cities and towns; 15 m. p. h. in other portions thereof; 20 m. p. h. in open country; must stop for frightened draught animal.

Non-Residents.—Exempt if own state tag is carried on rear.

TENNESSEE.

Registration.—With Secretary of State; fee, $2; certificate to be filed with County Clerk; fee, $1; transfer fees, $1 to state and 50 cents to county; owner provides number tags; numerals 3 inches high x ½ inch wide; plates, 4 inches x 7 inches; carried front and rear; no other tags to be carried.

Speeds.—20 m. p. h. which can be lowered by local authorities; must sound signal on overtaking draught animal and stop if same becomes frightened.

Non-Residents.—Required to register.

TEXAS.

Registration.—With County Clerk; fee, 50 cents; owner must provide tag having figures 6 inches high; one lamp forward from one hour after sunset to 1 hour before sunrise; signal carried must be one that can be heard 300 feet.

Speeds.—Always reasonable; 8 m. p. h. in built-up portions unless local authorities permit higher rate; 18 m. p. h. elsewhere; must stop on signal from person in charge of draught animal.

Non-Residents.—Not exempt.

UTAH.

Registration.—With Secretary of State at Salt Lake City; fee, $2; manufacturers, dealers and taxicab operators may register one machine of each style or type; duplicate seals, 50 cents; expires on sale, new owner may operate 10 days on old number; vendor may have number re-assigned, fee, $2; owner must notify of intention to sell; seal furnished must be displayed on car; number tag with numbers 4 inches high, stroke ½ inch wide and letter "U" 1 inch high must be carried stationary on rear; brakes and signal device required; must carry two white lights forward, one red light reverse, from 1 hour after sunset to 1 hour before sunrise.

Speds.—Always reasonable; 10 m. p. h. in built-up portions; 15 m. p. h. elsewhere in cities and towns; 20 m. p. h. in open country; 6 m. p. h. near highway intersections, bridge, dam, curve, dugway or steep descent; rates cannot be lowered by local authorities; must stop on signal from driver of horse; must give name and address in case of accident.

Non-Residents.—Temporary visitors exempt if home state tag is displayed on rear.

VERMONT.

Registration.—Annual with Secretary of State at Essex Junction; fee, first year, $1 per h. p.; second year, 75 cents per h. p.; thereafter, 50 cents per h. p.; after August 1, half rates; transfer extinguishes license; dealers' or manufacturers' annual fee, $25; operator's license fee, $2 annually; chauffeur's license fee, $2; every driver must be provided with either an operator's or chauffeur's license; license tags, white with black border and figures.

Speeds.—10 m. p. h. in built-up portions or 25 m. p. h. in open country is unreasonable; local regulations; joy riding prohibited.

Non-Residents.—Reciprocal exemption for 10 days if home state law is complied with; 10 to 60 day registration fees, $3 up to 20 h. p.; 21 to 29 h. p., $6, and $10 for cars of over 40 h. p.; when making over 60 day stay in state must register same as residents.

VIRGINIA.

Registration.—Annually with Secretary of Commonwealth at Richmond; duplicate certificate must be attached to machine; fees, 20 h. p. and under, $5; 20 to 45 h. p., $10; 45 h. p. or over, $20; motorcycles, $2; manufacturer's or dealer's registration fee, $50; non-transferable and expires on sale of car; professional chauffeur's license, $2.50; must display badge while operating; plate furnished having figures 4 inches high and letters "Va" to be attached to rear; brake, signal and locking device required, latter to be used when the car is left unattended; must carry one light visible 100 feet forward and red lamp reverse, throwing white light on number tag.

Speeds.—12 m. p. h. in township or city limits; 8 m. p. h. in built-up portions of same; in open country 20 m. p. h.; must slow up for horse and stop on signal from driver.

Non-Residents.—Reciprocal exemption for not exceeding two periods of seven consecutive days in each calendar year.

WASHINGTON.

Registration.—Annually before June 1 with Secretary of State at Olympia; fee, $2 number preceded by "WN" must be carried on rear; light numerals 4 inches high on dark ground; must carry brakes and bell or horn; one light after dark white forward with 1 inch numerals on glass and red reverse; use of cut-out not allowed in city limits.

Speeds.—Always reasonable; 12 m. p. h. in built-up portions; 4 m. p. h. over crossings in same; 24 m. p. h. in open country; must slow up for horse and stop on signal from driver; turn to right when overtaking vehicles or pedestrians.

Non-Residents.—Exempt if tag of home state is displayed.

WEST VIRGINIA.

Registration.—With State Auditor at Charleston, chauffeur's fee, $2; duplicate tags, $1; tags to be carried front and rear; all cars to be equipped with brakes, speedometers and signaling devices.

Speeds.—10 m. p. h. in cities and villages; 15 m. p. h. in semi-open country; 20 m. p. h. in open country; must stop on signal of horse driver and stop motor if neecessary.

Non-Residents.—Reciprocal exemption.

WISCONSIN.

Registration.—With Secretary of State at Madison; two certificates isued, one must be carried in car; fee, $2; transfer fee, $2; manufacturers' fee, $5; fee for motorcycles, $1; number tag furnished to be carried on rear; numerals 3 inches high, also letter "W" to be on tag; one lamp forward; brakes and signal device required.

Speeds.—12 m. p. h. in towns; 25 m. p. h. in open country; reduced at crossings, curves and descents; car must be stopped on signal from driver of horse; power must be shut off when car is left unattended on highway.

Non-Residents.—Exempt if tag of home state is displayed.

WYOMING.

No state law, regulations local.

CANADA.

The customs regulations governing the temporary admission of motor cars into Canada, as contained in memorandum No. 1571B, in force April 1, 1910, and reprinted below, require generally a bond for double the estimated duties and a deposit of $25. For motor cars remaining in Canada not more than 3 days, a permit is issued, apparently without deposit or bond.

1. Motor cars manufactured abroad and not duty paid, when imported into Canada by the owners personally who are non-residents of Canada or temporary visitors therein, may be admitted under bond or upon cash deposit, for owners for touring purposes only, provided the owner is in nowise connected with any motor car business and that the machine is not to be used for any commercial or business pursuits whatever while in Canada, and subject to the following regulations and conditions:

(a) The motor car shall be reported on form approved (E. 29½) in duplicate, at the customhouse at the port of importation, where a careful examination and appraisement shall be made.

(b) An invoice showing the selling price of the motor car shall be produced when practicable, as an aid to the collector in determining the value.

(c) Upon receiving a deposit of $25 and a bond executed in Canada in approved form for double the estimated duties, conditional for the due exportation of the motor car covered thereby within 3 months from date of bond, the collector may grant a permit accordingly, to be indorsed on the duplicate report, for the use of the motor car in Canada for touring purposes.

(d) The bond shall be signed by the importer and by two residents; or by the importer and by a resident of Canada who has deposited with the collector of the port of entry the general guaranty of an incorporated guaranty company authorized to do business in Canada, and which guaranty is then available as a security in the case; provided that the special bond of an incorporated guaranty company authorized to do business in Canada may also be accepted, in approved form, instead of the bond first herein mentioned, and that the cash deposit of $25 may be dispensed with in any case covered by a special or general guaranty bond.

(e) The bond shall be filed by the collector with the tourist's report attached, and the duplicate report shall be handed to the tourist with permit and receipt for deposit indorsed thereon.

(f) The deposit shall be subject to refund by the collector upon return of permit with proof of the exportation of the motor car within 3 months from date of bond. In default of the exportation of the motor car with proof of such exportation to the satisfaction of the collector within 3 months from the date of importation, the deposit is to be entered as customs duty and the provisions of the bond enforced.

(g) The term "motor car" herein is to be held as including the outfit accompanying the motor car.

3. Motor cars manufactured abroad and not duty paid may not be reimported for touring purposes within 6 months from the time of their exportation after previous entry in bond for touring purposes. This limitation, however, shall not apply to motor cars provided for in the section next following.

4. The regulations in memorandum 940B of July 31, 1897, concerning teams and carriages crossing the frontier, provide that where the persons in charge of such teams and carlages are well known to the customs officer he may allow the outfit to cross the frontier and return within 1 week, subject only to the usual report, search and xamination. This provision may be extended to tourists' motor cars when the customs officer is satisfied that the motor cars will be used only within the limits of the port of importation and vicinity in conformity with customs, laws and regulations.

HORSE POWER FOR INTERNAL COMBUSTION MOTOR AUTOMOBILES

CALCULATED FROM FORMULA:

$$\text{H. P.} = \frac{(\text{DIAM. IN INCHES})^2 \times \text{NUMBER OF CYLINDERS}}{2.5}$$

BORE		HORSE POWER			
INCHES	MILLIMETERS	1 CYLINDER	2 CYLINDERS	4 CYLINDERS	6 CYLINDERS
2½	64	2.5	5.0	10.0	15.0
⅝	68	2.8	5.5	11.0	16.5
¾	70	3.0	6.0	12.1	18.1
⅞	73	3.3	6.6	13.2	19.8
3–	76	3.6	7.2	14.4	21.6
⅛	79	3.9	7.8	15.6	23.4
¼	83	4.2	8.4	16.9	25.3
⅜	85	4.6	9.1	18.2	27.3
3½	89	4.9	9.8	19.6	29.4
⅝	92	5.3	10.5	21.0	31.5
¾	95	5.6	11.2	22.5	33.7
⅞	99	6.0	12.0	24.0	36.0
4–	102	6.4	12.8	25.6	38.4
⅛	105	6.8	13.6	27.2	40.8
¼	108	7.2	14.4	28.9	43.3
⅜	111	7.7	15.3	30.6	45.9
4½	114	8.1	16.2	32.4	48.6
⅝	118	8.6	17.1	34.2	51.4
¾	121	9.0	18.0	36.1	54.2
⅞	124	9.5	19.0	38.0	57.0
5–	127	10.0	20.0	40.0	60.0
⅛	130	10.5	21.0	42.0	63.0
¼	133	11.0	22.0	44.1	66.1
⅜	137	11.6	23.1	46.2	69.3
5½	140	12.1	24.2	48.4	72.6
⅝	143	12.7	25.3	50.6	75.9
¾	146	13.2	26.4	52.9	79.3
⅞	149	13.8	27.6	55.2	82.8
6–	152	14.4	28.8	57.6	86.4

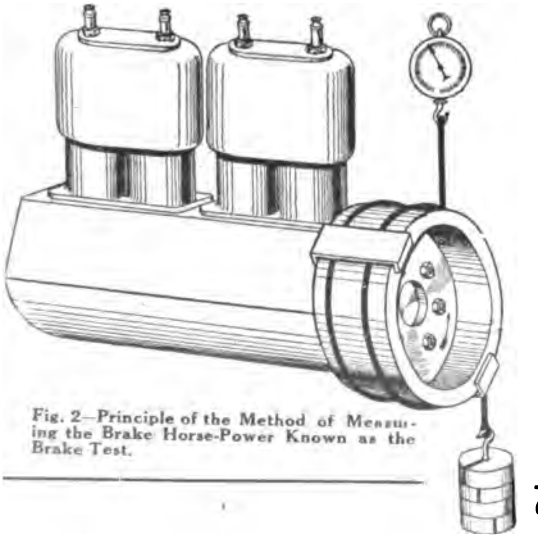


Fig. 2—Principle of the Method of Measuring the Brake Horse-Power Known as the Brake Test.

AN ENGLISH METHOD FOR FINDING THE HORSE POWER

These indicated h.p. tables, by Mr. Worby Beaumont, are worked out for two speeds—the top horizontal line for each size of engine being at 750 revolutions, and the lower line at 1,000 revolutions. As an example. A cylinder is 4in. bore and 4in. stroke; the power at 750 revolutions will be found opposite the figure 4 and under vertical column 0 (Table II.). It is given as 4.27 h.p. Just below it appears 5.71, which is the horse-power at 1,000 revolutions. Suppose the cylinder is 4 in. stroke × 5¼ in. bore; look along the horizontal column opposite 4 till the seventh vertical column is reached (each representing ¼ in. increase in stroke); the figure 5.89 h.p. at 750 revolutions, and 7.85 at 1,000 revolutions. The results given are for a single cylinder. For multi-cylinder engines the power found in the table must be multiplied by the number of cylinders. [Note.—The figures on top horizontal line are increases, and always to be *added* to the figures in first vertical line.]

TABLE II.

Bore.	0	¼	½	¾	1		½	¾	2 in.
in. 2	0·54	0·60	0·67	0·74	0·81	0·88	0·94	1·01	1·08
	0·72	0·80	0·89	0·98	1·08	1·17	1·25	1·35	1·44
2¼	0·76	0·84	0·92	1·01	1·09	1·18	1·26	1·35	1·43
	1·01	1·12	1·22	1.34	1·45	1·57	1·68	1·81	1·90
2½	1·04	1·15	1·25	1·35	1·46	1·56	1·67	1·77	1·88
	1·39	1·53	1·67	1·81	1·95	2·09	2·23	2·37	2·51
2¾	1·39	1·51	1·64	1·77	1·89	2·02	2·14	2·27	2·40
	1·85	2·02	2·19	2·36	2·53	2·70	2·87	3·04	3·20
3	1·80	1·95	2·10	2·25	2·40	2·55	2·70	2·85	3·00
	2·40	2·60	2·80	3·00	3·21	3·40	3·61	3·81	4·00
3¼	2·30	2·47	2.65	2·82	3·00	3·18	3·36	3·53	3·70
	3·06	3·28	3·52	3·76	3·99	4·22	4·45	4·70	4·93
3½	2·86	3·06	3·27	3·48	3·68	3·88	4·09	4·30	4·50
	3·81	4·09	4·36	4·63	4·90	5·18	5·45	5·72	6·00
3¾	3·53	3·76	4·00	4·35	4·47	4·71	4·95	5·18	5·41
	4·71	5·02	5·34	5·65	5·97	6·28	6·60	6·91	7·23
4	4·27	4·55	4·81	5·08	5·35	5·61	5·89	6·15	6·41
	5·71	6·06	6·42	6·78	7·13	7·50	7·85	8·20	8·55
4¼	5·13	5·44	5·74	6·04	6·34	6·64	6·95	7·25	7·55
	6·84	7·24	7·64	8·05	8·45	8·85	9·25	9·65	10·06
4½	6·19	6·53	6·87	7·22	7·56	7·90	8·25	8·59	8·93
	8·25	8·68	9·16	9·62	10·08	10·54	10·96	11·41	11·89
4¾	7·18	7·55	7·94	8·31	8·70	9·07	9·45	9·82	—
	9·57	10·07	10·57	11·09	11·58	12·08	12·59	13·09	—
5	8·38	8·80	9·22	9·65	10·06	10·46	10·90	—	—
	11·16	11·72	12·28	12·84	13·40	13·95	14·50	—	—
5¼	9·70	10·16	10·62	11·09	11·54	12·00	—	—	—
	12·92	13·54	14·15	14·76	15·40	16·00	—	—	—
5½	11·12	11·65	12·15	12·66	13·15	—	—	—	—
	14·84	15·51	16·20	16·86	17·54	—	—	—	—
5¾	12·71	13·27	13·82	14·38	—	—	—	—	—
	16·96	17·70	18·42	19·19	—	—	—	—	—
6	14·46	15·06	15·65	—	—	—	—	—	—
	19·25	20·05	20·85	—	—	—	—	—	—

CHART No. 171

INSTRUCTION No. 38

HORSE POWER :—How to Calculate Horsepower. How to Read a Taximeter. Rule and Tables.

HORSE POWER EXPLAINED.

The Power Unit Used in Motor Work is a standard rate of doing mechanical work, equal to 33,000 lbs. mass (or weight) raised through a height of 1 foot in 1 minute; or if we move 16,500 lbs. through 2 feet or any proportionate ratio which multiplied together equals 33,000 in the same time, it is also equal to working at the rate of 1 horse power.

This Means that, theoretically, if the speed of a motor car engine could always be kept constant, and thus be giving uniform power, this power could be utilized to move any load up any gradient by taking a proportionately longer time to do it, providing that the car had a perfect all-speed gear.

This Principle Is, as far as possible, realized by the change-speed gear of a car which gives a range of three or four speeds.

A Car When Running possesses momentum, or stored energy; and to overcome this when desirable, brakes are fitted to the wheels.

The Brakes Quickly Convert the mechanical energy into heat energy, and the car is brought to rest.

Wind Resistance has a very important bearing upon the speed at which a car can run for a given amount of power.

The Resistance Increases in proportion to the "square" of the speed: thus at 20 miles per hour it is four times what it is at 10 miles, and at 30 miles per hour nine times, and so on.

HORSE POWER ABBREVIATIONS.

Every Engine Uses a certain per cent of its total power to drive itself.

I. H. P.—Indicated Horse Power, is A. H. P. plus the power an engine requires to drive itself.

Indicated Horse Power Is Determined by an instrument called an INDICATOR attached to the compression chamber of the cylinder, which is capable of indicating the pressure behind the piston by tracings on a card. The power is figured from the area of this tracing.

A. H. P.—Actual Horse Power, means the power an engine has to spare for driving other machinery after driving itself.

B. H. P.—Brake Horse Power, same as A. H. P.

Total Power of an Engine is the same as its I. H. P.

If an Engine Develops on Brake Tests, even Brake Horse Power, or Actual Horse Power, and it takes 3 H. P. to drive itself, it is therefore properly called a ten indicated and seven actual or Brake Horse Power.

Horsepower is an art which had its inception with the gasoline motor, and since then has been going through a phenomenal process of evolution.

Horsepower, Today, according to the manufacturer's catalog, is one of the vaguest quantities; and according to the best accepted formula it is almost as uncertain. To the person whose conception of 1 horsepower is limited to raising 3,300 pounds 1 foot in 1 minute the catalog rating of 50 to 70 horsepower has little value or meaning.

HOW TO CALCULATE HORSE POWER.

To Calculate Exactly the horse power of a gasoline automobile engine is, of course, almost impossible.

No Matter What the Formula Used, there must be some trifling error, depending upon, if nothing else, the number of revolutions made per minute by the engine.

Probably the Only Way of Learning the Exact Horse Power of any engine is by actual test upon a mechanical machine.

It Is Possible, However, to Estimate the Horse Power of any engine within a reasonable degree of accuracy.

Of the Several Formulas promulgated for this purpose, the one now used to the greatest extent in the United States is the A. L. A. M. formula.

A. L. A. M. HORSE POWER FORMULA.

The A. L. A. M. Horse Power Rating, as shown in Chart 171, does not mention the length of the stroke, the stroke not entering into formula excepting in that this horse power rating was based on a piston. speed of 1,000 feet per minute, so that the longer the stroke the few the number of revolutions per minute or speed of the motor.

A. L. A. M Means Associated Licensed Automobile Manufacturers. This is really the standard for this country.

For Instance, to Find the H. P. of a 4-Inch, 4-Cylinder Engine, we follow the formula shown in Chart 171. Square the diameter of piston by multiplying 4x4=16, then multiply this by the number of cylinders (4) and we have 64, then divide this by 2.5 and we have 25.6 horsepower.

The Above Is Based on a piston speed of 1,000 feet per minute.

The Above Method of Determining Horsepower is the quickest and possibly the best for general use.

THE BRAKE TEST.

FOR FINDING THE ACTUAL HORSE POWER.

The Measurement of the Brake-Horsepower (b. h. p.) of motors may be made by a simple "brake" test, as follows:—A rope is passed once around the clutch drum of the motor, and one end secured to a spring balance which is hooked to a support just above the clutch drum. To the other end of the rope is attached a scale pan, into which weights can be placed. (See Fig. 2, Chart 171.)

This Weight Is Applied until the engine is pulling all it will pull without materially reducing the speed, and the weights on each side balance or hang clear of the floor.

The Engine Is Then Left Running under its load for from ten to thirty minutes, during which time the speed is counted a number of times, to determine whether the engine holds the same speed.

When You Have Maintained the Same Speed for some time the test may be concluded by stopping the engine.

The Weights on Each End are then weighed and the difference in pounds is the number of pounds pulled by the engine.

By multiplying the circumference of the wheel, in feet, by the number of pounds pulled by the number of revolutions per minute, and dividing this product by 33,000, the result will show the ACTUAL or BRAKE HORSEPOWER of the engine.

FOR EXAMPLE.

The Diameter of Fly Wheel is 30 inches or 2½ feet.

Now Get the Circumference by multiplying the diameter by 3.1416; therefore 2½x3.1416 equals 7.85 ft.

The Pounds Pulled was the difference between 20 and 72, which was 52.

The Speed, 300 R. P. M. or revolutions per minute.

Now multiply 7.85 (ft.) x52 (pounds) x300 (speed) and we have 37.10 H. P.

A Power capable of raising one foot high, in one minute, equals one horse power.

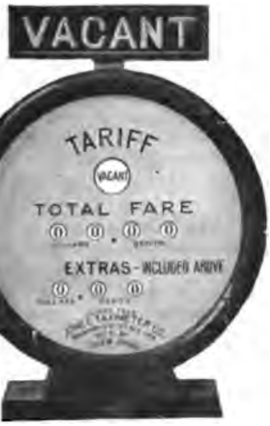


Fig. 1 A Taximeter at Vacant Position

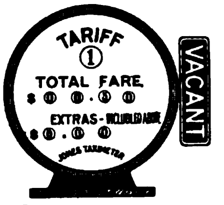


Fig. 2—Taximeter Starting with Tariff Sign Showing One Fare or Passenger. First charge of 30c for the first half mile is recorded when the vacant sign is first turned to the right. 10c is charged for each ¼ mile additional.

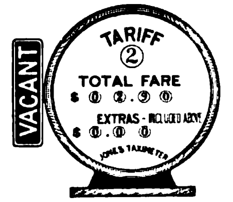


Fig. 3 — Taximeter with Three or More Persons. Tariff shows (2) meaning two fares. The "Vacant" sign is turned to the left in this case. 30c being the charge fee the first one-third of a mile and 10c for each 1-6 mile.

HOW TO READ A TAXIMETER.

When Car Is Standing the meter is shown with the vacant sign standing upright and all dials at zero.

When Car Starts on Trip With One or Two Persons, the "Vacant" sign is turned to the right, as shown in Fig. 2.

The Tariff Shows a Figure 1, which means one fare to be charged.

The Total Fare registers 30c which is the charge for the first, one-half mile, and which is made when the vacant sign is first pulled to the right.

After the First Half-Mile charge is recorded, the instrument automatically charges 10c for each additional quarter mile.

In Case a Trunk Is Carried, the driver turns the knob on the reverse side of the instrument, which causes the trunk charge to be recorded, in the "extra" space, and also adds this amount of extra to the "total fare" already recorded.

After the Passenger Leaving the Taxicab and paying the fare, the vacant sign is returned to vertical position and figures again go to zero.

When Three or More Persons Enter a Taxicab, the "vacant" sign is turned to the left as shown in Fig. 3. The initial charge of 30c being the charge for the first one-third mile and additional 10c for each additional one-sixth mile. (note difference of one fare and double fare charge.)

When Taxicab Is Kept Waiting, there is a clock mechanism which, when the "vacant" sign is down and the vehicle standing, a charge of 10c is registered for the first 6 minutes, and a similar charge for each additional 6 minutes of waiting.

Finding the Gradient of a Hill

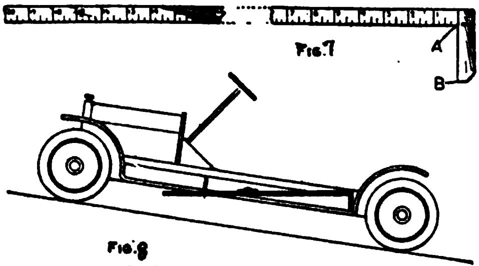


FIG. 1

FIG. 2

Finding the Grade of a Hill

This can be readily done with the assistance of a level and a piece of straight timber, a lath will do. First run the car on a perfectly level floor and have the tires all pumped up to normal. The foot-board should be made parallel with the floor, that is, horizontal. Obtain a piece of lath ⅛ inch thick, 2 in wide and 5½ ft. long, and have the edges planed true and straight. Fasten a small piece of wood firmly at right angles on one end of this lath. The piece should extend 2½ or 3 in. below the edge of the long piece. Along the bottom edge of the long arm mark off at a number of points the exact distance apart that the short arm projects below the long arm, or from A to B.

If the short arm projects 3 in., a 5 ft. long arm will give twenty readings. These can be again subdivided into as many parts as the accuracy desired may require. With this simple affair and an ordinary level take the car to the center of the slope you wish to measure. Stop on the slope, stand the short arm on the edge of the footboard near the rear wing, fig. 2. Place the level on top of the long arm, and when the long arm is moved to be exactly horizontal, read off the figure of the division cutting the rear edge of the footboard This gives the slope, expressed as a fraction, viz., 1-20, 1-14, 1-17½, etc. This operation can be repeated on every change of slope, and if the surface distance between each change of slope be taped, the section of the hill can be easily plotted. If it be desired to express the slopes thus found in degrees, sufficient accuracy is obtained up to 20 deg. by dividing the denominator of the fraction into 60. Thus a slope of ¼ equals 15 deg., 1/6 equals 10 deg., ⅛ equals 7½ deg., all approximate.

Gradients.

A grade of	1 in 5	equals	20	per cent., or angle of	11° 19′
„ „	1 in 6	„	17	„ „	9° 26′
„ „	1 in 7	„	14	„ „	8° 09′
„ „	1 in 8	„	12½	„ „	7° 08′
„ „	1 in 9	„	11	„ „	6° 17′
„ „	1 in 10	„	10	„ „	5° 43′
„ „	1 in 11	„	9	„ „	5° 11′
„ „	1 in 12	„	8	„ „	4° 46′
„ „	1 in 13	„	7¾	„ „	4° 24′
„ „	1 in 14	„	7	„ „	4° 05′
„ „	1 in 15	„	6⅔	„ „	3° 49′
„ „	1 in 16	„	6¼	„ „	3° 35′
„ „	1 in 17	„	6	„ „	3° 22′
„ „	1 in 18	„	5½	„ „	3° 11′
„ „	1 in 19	„	5	„ „	3° 00′
„ „	1 in 20	„	5	„ „	2° 52′

Conversion of Metric into English Measure

1 millimetre is approximately 1/25 inch and is exactly ·03937 inch.
1 centimetre is approximately 10/25 inch and is exactly ·3937 inch.
1 metre is approximately 39⅜ inches and is exactly 1·0936 yards.
1 kilometre is approximately ⅝ mile and is exactly ·6213 mile.
1 kilogramme is approximately 2¼ lbs. and is exactly 2·21 lbs.
1 litre is approximately 1¾ pints and is exactly 1·76 pints.

To convert metres to yards, multiply by 70 and divide by 64.

To convert kilometres to miles, multiply by 5 and divide by (approx.).

To convert litres to pints, multiply by 88 and divide by 50.

To convert grams to ounces, multiply by 567 and divide by

To find the cubical contents of a motor cylinder, square the diameter (or bore) multiply by 0·7854 and multiply the result by the stroke.

Tyre Sizes: Equivalents in Millimetres and Inches

26 inches	=	650	millimetres	2¼ inches	=	60	millimetres
28 „	=	700	„	2½ „	=	65	„
30 „	=	750	„	3 „	=	80	„
32 „	=	800	„	3¼ „	=	85	„
33 „	=	840	„	3½ „	=	90	„
34 „	=	870	„	4 „	=	100	„
36 „	=	910	„	4¼ „	=	105	„
40 „	=	1010	„	5 „	=	120	„

Nominal sizes only.

TABLE OF CYLINDER BORES AND STROKES IN MILLIMETRES AND INCHES.

The following figures are approximate, and intended only as a rough guide for comparison. For accurate measurements a sliding calliper with inches and metric scales should be used:

A Cylinder		Equals in Inches	A Cylinder		Equals in Inches
66 by 70 millimetres	...	2 9/16 by 2¾	84 by 90 millimetres	...	3 5/16 by 3 9/16
67 „ 70 „	...	2⅝ „ 2¾	90 „ 90 „	...	3 9/16 „ 3 9/16
67 „ 73 „	...	2⅝ „ 2⅞	90 „ 110 „	...	3 9/16 „ 4 5/16
67 „ 77 „	...	2⅝ „ 3	95 „ 115 „	...	3¾ „ 4 9/16
70 „ 70 „	...	2¾ „ 2¾	100 „ 115 „	...	3 15/16 „ 4 9/16
70 „ 73 „	...	2¾ „ 2⅞	105 „ 118 „	...	4⅛ „ 4⅝
70 „ 77 „	...	2¾ „ 3	108 „ 120 „	...	4¼ „ 4¾
72 „ 77 „	...	2 13/16 „ 3	110 „ 125 „	...	4 5/16 „ 4 15/16
73 „ 73 „	...	2⅞ „ 2⅞	112 „ 128 „	...	4 7/16 „ 5 1/16
73 „ 80 „	...	2⅞ „ 3⅛	114 „ 130 „	...	4½ „ 5⅛
77 „ 77 „	...	3 „ 3	116 „ 134 „	...	4 9/16 „ 5 5/16
77 „ 80 „	...	3 „ 3⅛	118 „ 136 „	...	4⅝ „ 5 7/16
77 „ 83 „	...	3 „ 3¼	120 „ 140 „	...	4¾ „ 5½
78 „ 78 „	...	3 1/16 „ 3 1/16	122 „ 143 „	...	4 13/16 „ 5⅝
80 „ 80 „	...	3⅛ „ 3⅛	124 „ 146 „	...	4⅞ „ 5¾
80 „ 86 „	...	3⅛ „ 3⅜	126 „ 148 „	...	4 15/16 „ 5 13/16
83 „ 83 „	...	3¼ „ 3¼	128 „ 150 „	...	5 1/16 „ 5 15/16
83 „ 86 „	...	3¼ „ 3⅜	130 „ 152 „	...	5⅛ „ 6
86 „ 86 „	...	3⅜ „ 3⅜	140 „ 160 „	...	5½ „ 6¼

How to Find the Gradient. Metric into English Measure

CHART No. 172

INSTRUCTION No. 39

STEAM BOILERS. STEAM ENGINES. AIR CRAFTS.

GENERAL CONSTRUCTION OF A STEAMER.

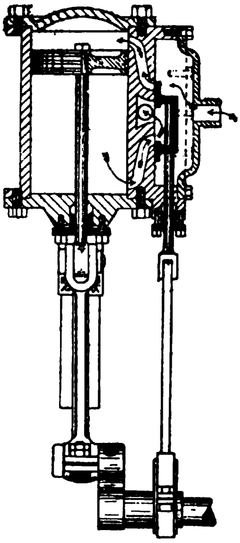
The Transmission arrangements of steam cars in general do not differ essentially from gasoline-propelled cars beyond the omission of the clutch.

Either a Chain Drive or propeller shaft can be used.

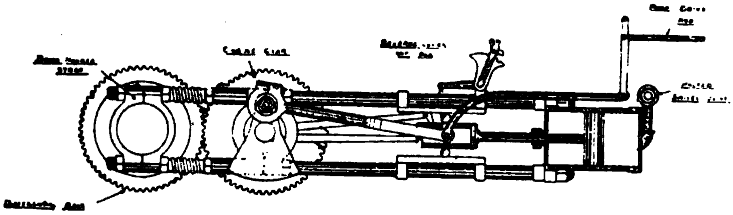
There Are a Few Steam Cars fitted with a change-speed gear providing a very low speed which might be required in exceptional cases.

Regulation of speed is entirely effected by the throttle valve acting on the steam supply.

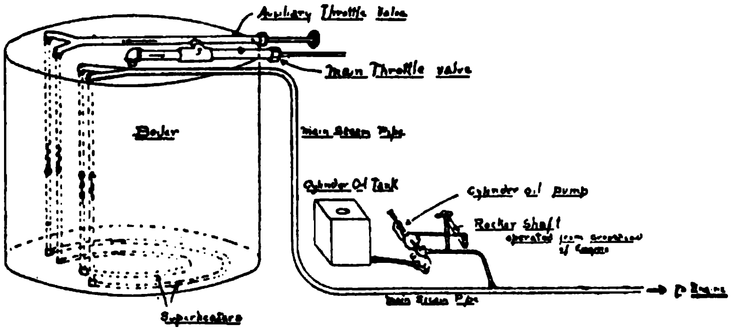
Mention Must Be Made of the fact that the high and low-pressure system of cylinders, as adopted on railroad locomotives, has been successfully applied to steam cars, as in the White.



Sectional view of single-cylinder double-acting steam engine. The admission of steam is controlled by the slide valve seen on the right, which admits it alternately on the front and rear of the piston. This valve is operated by an eccentric and connecting rod from the main crank shaft. The piston rod, it will be seen, works through a steam-tight stuffing box and drives the connecting rod from a cross-head working on a slide.



Double-acting horizontal engine driving direct on to rear axle, as used on the Stanley Steam Car.



High-pressure multitubular boiler system (but main tubes nol shown.)

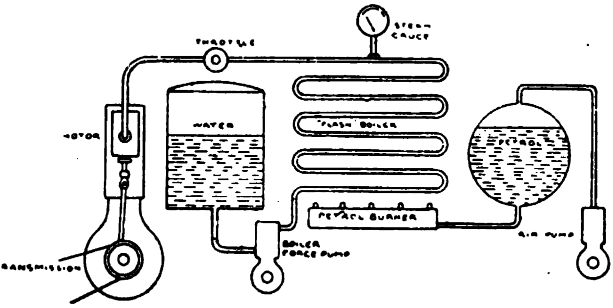


Diagram of general arrangement of steam generator of "flash" type.

As a Rule steam cars use more fuel in a given distance than a gasoline car of the same weight and power, but this drawback is to a large extent counterbalanced by the ability of the burners to consume a cheaper grade of fuel such as kerosene, or crude gasoline.

The Machanism of a Steam-Driven Car differs considerably from a gas car, the driving power being generated in a less direct manner.

The Chief Features of a steam car are a high-pressure steam boiler or generator, and a doublelcylinder steam engine to utilize the energy produced.

It Has No Variable-Speed Gear, or electric ignition system.

THE CHIEF COMPONENTS

are the engine, boiler or steam generator, and heater, pumps, transmission gear, water and gasoline supply tanks, and controlling gear. These are mounted upon the framework of the car, the boiler and engine usually being fixed in a vertical position.

The Steam Engine has certain details in common with the gasoline engine, such as the cylinder, piston, connecting rod, crank, etc.

The Flywheel and Clutch, valve and ignition gearing and sparking-plug are not fitted.

Steam at High Pressure is admitted to the cylinders alternately on the back and front of the pistons by means of a sliding valve, which is actuated by eccentrics keyed to the main shaft.

A Special Advantage of a Steam Engine is the facility with which its direction of rotation can be reversed by causing the steam to enter either at the back or forward end of the cylinder as desired by means of a mechanism, termed the link motion.

No Fly-Wheel Is Necessary, the action of the engines being perfectly uniform; with two cylinders four impulses are obtained for every revolution of the crankshaft.

In Some Types of Steam Cars the drive is taken off a chain wheel or sprocket keyed to the center of the shaft at the usual type of rear live axle.

MULTI-TUBULAR BOILERS

One Usual Form of Steam Generator or boiler is powerful and compact, constructed upon the multi-tubular system, in which a large number of metal tubes are fixed within the cylindrical body of the boiler, and through these heat generated by a gasoline burner passes.

The Water Surrounds These Tubes, thus coming in contact with a very large heating surface, and steam can be quickly raised and maintained at high pressure. The working pressure is 250 lb. to 400 lb. per square inch, an automatic regulator keeping the pressure constant.

This Regulator acts upon the burner by cutting down or increasing the fuel supply.

A Safety Valve is also provided, which acts automatically when the pressure reaches a certain valve.

THE "FLASH" BOILER.

The High Pressure Steam Generators are also constructed on the "flash" system, in which a coil of very stout section steel or copper tube is raised to a high temperature by a special type of burner, and a stream of water pumped into it at fixed periods.

The Water Is Thereby Flashed into steam at a very high pressure, and conveyed into the cylinders of the engine.

"RUNABOUT" TYPE.

Boilers of the Light or "Runabout" Type of steam cars are constructed of copper throughout, and tested up to a high pressure, so that any risk of bursting is practically non-existent.

To Enable the Driver to Be Sure of the Quantity of Water in the boiler, a gauge glass is provided, fitted with check valves, in case of breakage.

THE SERPOLLET.

An interesting feature of the Serpollet engine is that the steam is admitted to the cylinder through ordinary "poppet" valves, as in a gasoline engine.

The Very High Temperature of the steam renders the use of a slide valve impracticable.

THE WHITE STEAM CAR.

The White Steam Car, which is about the most widely-used of American makes, in outward appearance closely resembles a gasoline car.

The Boiler—A Semi-Flash Type—has a series of coiled steel tubes heated by an oil burner.

The Fuel and Water Feed are automatically regulated.

The Exhaust Steam is condensed in a radiator placed in front of the car just as in a gasoline car.

The Engine is of the double-acting, twin-cylinder, "compound" pattern, having high and low-pressure, driving through a live axle.

The Valves are of the piston type, and ball bearings are fitted. Gasoline or kerosene may be used as fuel.

In the 15 H. P. Model the water tank carries a supply for 150 miles.

Initial Pressure is raised by a hand pump forcing water into the generator.

The Steam Pressure and fuel supply to the burner are automatically controlled by special valves.

For Special Emergencies, a reserve low gear is provided, although all ordinary hills can be easily be taken direct, the engine and generator having an ample range of power output.

THE STANLEY STEAMER.

A typical Example of the light steam car in which the steam is generated in a high-pressure, multi-tubular boiler is the Stanley.

Heat is Obtained from a gasoline burner, which is automatically supplied with fuel from a pressure tank and pump.

The Steam Generated is passed through superheaters, by which the temperature and pressure are increased.

Water is Supplied to the Boiler by an automatic pump, and a hand pump is fitted as a reserve.

The Boiler is Fitted With a Safety Plug made of fusible metal, which automatically blows out in the event of the water in the boiler falling to an unsafe level.

The Steam Pressure in the boiler being released by the plug blowing, the car would come to a stop, and the operation would at once shut off the gasoline burner, and thus prevent the boiler being damaged.

The Engine is a Special Type, double-acting, fitted with ball bearings at all frictional points, including the cross-head slides and connecting rod ends.

The Transmission to the road wheels is on the simplest possible lines.

The Engine is Mounted Horizontally on a swivel joint, as illustrated, and it will be noticed that the crankshaft carries a gear wheel.

This Engages a Similar Gear Wheel carried on the differential back axle of the car, so that practically the engine drives direct on the axle without the intervention of any clutch, change gear, jointed shaft or bevel gearing.

The Motion of the Engine is Reversed by the eccentric mechanism acting on the slide valve.

AIR CRAFTS.

The Popular Types of Air Crafts are divided into two classes; those lighter than air, and those that are heavier than air.

The Lighter Than Air Type include the Balloon and the Dirigible airship.

The Heavier Than Air Type include the Bi-Plane and Mono Plane.

The Propulsion of both the Dirigible Type and the Plane Type, is by means of a gasoline engine driving a propeller.

The Aeroplane is most in favor and there are two popular types of Aeroplanes; the Monoplane and the Bi-plane.

The Monoplane is illustrated in Fig 3. This type has but one plane, and that is where it derives its name; "mono" meaning alone or one.

The Biplane has two planes, "Bi" meaning two. See Fig. 2.

In order that aerpolanes may fly at all, every monoplane and biplane must have a main supporting surface; a horizontal rudder or elevator, by means of which the machine is guided up or down; a vertical rudder, by means of which the machine is kept on an even course and turned from side to side, and some means whereby the amount of main surface exposed to the pressure of the air can be varied, so as to preserve side to side balance. To these essential elements a tail, consisting of a horizontal surface, is frequently added, because it steadies the machine in flight, even though at the expense of power and speed.

The Monoplane is the machine for speed. Whereas the Biplane is the slower, but it is the machine that will be called upon to carry increasingly heavy loads by the aerial way, and that will become the touring machine of the skies.

The Zeppelin Airship is explained in Fig. 1; the main feature being that the outer shell is made of aluminum framework covered with an outer skin. 17 gas bags are contained inside. No matter whether deprived of the gas bags or not the contour remains the same.

The propellers are operated by 2 four-cylinder 85 h, p. engines. 30 miles per hour is attained.

There are 4 propellers. They are 3 bladed and 10 feet in diameter.

See Chart 173 for illustration of each type.

On Chart 51D the Gnome Aerial Engine is described. This engine is made especially for aerial work.

*For further information on Air Crafts address, Aero Publication Co., St. Louis, Mo.

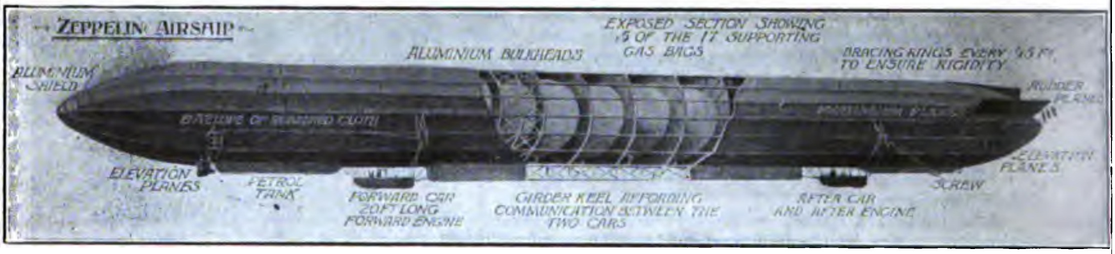

ZEPPELIN AIRSHIP
EXPOSED SECTION SHOWING 5 OF THE 17 SUPPORTING GAS BAGS
ALUMINIUM BULKHEADS
BRACING RINGS EVERY 45 FT. TO ENSURE RIGIDITY
ALUMINIUM SHIELD
RUDDER PLANES
ELEVATION PLANES
ELEVATION PLANES
PETROL TANK
FORWARD CAR 20FT LONG FORWARD ENGINE
GIRDER KEEL AFFORDING COMMUNICATION BETWEEN THE TWO CARS
AFTER CAR AND AFTER ENGINE
SCREW

Fig. 1—A **Dirigible** type of air craft, "lighter than air."

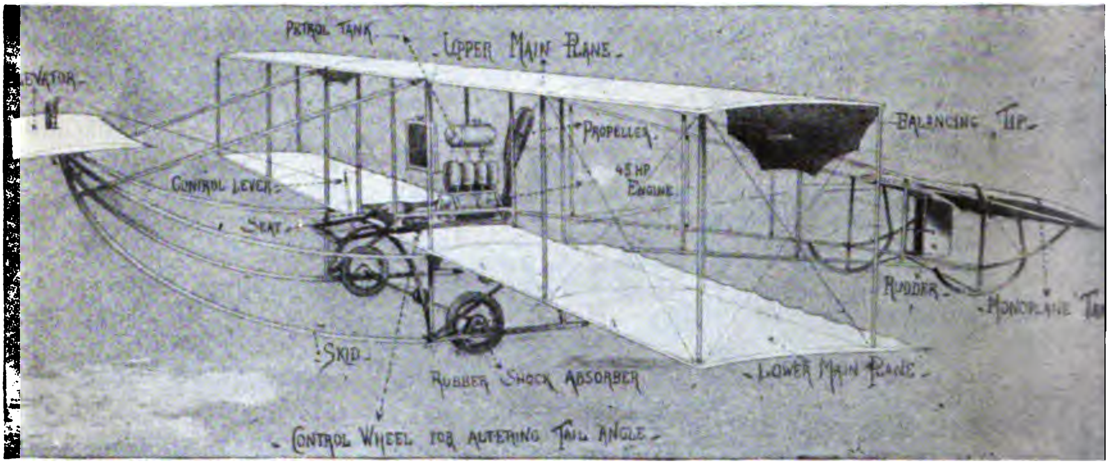


Fig. 2—A **Biplane** (meaning two planes) motor propelled "heavier than air" type of aircraft.

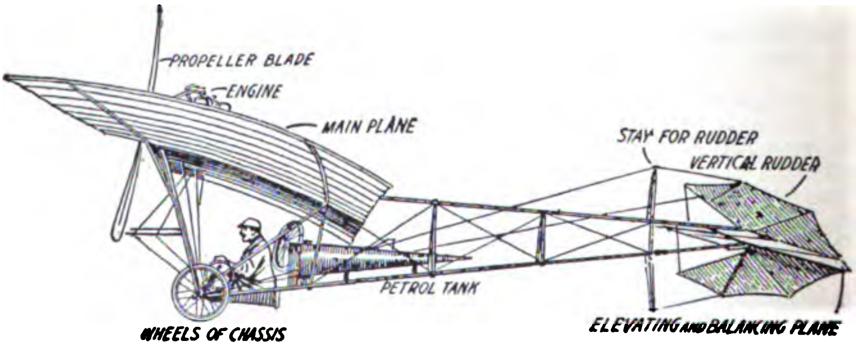


Fig. 3—A **Monoplane** (meaning one plane) motor propelled "heavier than air" type of aircraft.

Air Crafts

CHART No. 173

INSTRUCTION No. 40.

MOTOR DICTIONARY:—Meaning in Plain English of Some of the Words Used in Connection With the Automobile. Specifications of Some of the Leading 1912 Cars.

NOTE:—If the Dictionary does not give the meaning, or if a description is desired, —see index for the subject.

A

Accumulators—A set of secondary cells, also called storage batteries, containing positive and negative plates, and filled with electrolite. These cells are charged with electricity and can be recharged as often as run down, either by means of a dynamo or by a powerful primary battery, so long as the plates and electrolite are in good condition.

"Actual" Horse-power is the amount of power that would be available if there was none absorbed by friction within the motor itself, and the total energy of the explosion was transmitted without friction or other losses to the motor shaft.

Advanced Lever.—This term is usually applied when the spark lever is pushed forward or advanced. When lever is advanced, the timer or the breaker box is moved forward and causes earlier ignition.

Alternating Current—Usually applied to the current obtained from magneto—not steady but alternately from positive to negative and back again. Also applied to electric light currents.

Ampere—Unit for measuring the quantity of electricity. Meaning the QUANTITY of current. It is a unit that may be compared with the gallons per minute unit.

Ampere-hour Capacity of an accumulator is a term used to express the amount of current that can be got out of an accumulator of a given size. An actual 50 ampere-hour accumulator should be capable of giving 1 ampere for 50 hours, 2 amperes for 25 hours; but the ratio becomes disproportionate as a higher rate of current is taken from the cell.

Annealled—Softening of iron—by placing wire or iron in a fire and getting it red hot and then permitting it to cool without water it softens. The core of a coil is made of bundles of annealled iron wire.

Automatic Inlet Valve—Valve placed in the top of a cylinder, and which admits gas to the cylinder by suction of the piston.

B

Battery—A number of cells connected together in series so that the current given shall be equal to their combined voltage.—A storage Battery or a Dry Battery—either consists of 2 or more cells.

Battery Switch—A switch is usually placed on coils on cars on the dash, using magneto and batteries. One side is the "Battery Switch" and the other side "Magneto Switch."

Back-Firing often happens in the muffler and sometimes in the carburetor, caused by weak spark not igniting and inlet valve opening too early.

Back-Pressure—Term applied to exhaust discharge. Unless muffler is of sufficient size there will be back pressure, and the exhaust will not be discharged as rapidly as it should.

The Bore and Stroke of a Motor (Cylinder) are, usually, expressed in millimetres, a more scientific unit of measurement than adopting fractions of an inch—1 millimetre may be taken as equivalent to 1-25th part of an inch when moderate accuracy is required. The bore of a cylinder is the measurement across the circular space in which the piston moves. It is another way of expressing the internal diameter of the cylinder. The **Stroke** is the length of the path through which the piston moves in the cylinder, and is exactly equal to the diameter of the circle made by the crank pin.

Brakes are divided into 2 classes. "Running Brake," meaning the brake used more frequently—it is the foot brake. The "Lever Brake" or "Emergency" is the other.

B. R. H.—Brake Horse Power—Measurement of horse power of an engine of actual net work of the engine or horse power delivered at the shaft. Usually measured with a "brake" system around the fly wheel.

C

Cam—An oval shaped piece of steel with a nose which raises the exhaust valves.

Cam-Shaft—The shaft running through the engine and which has the cams placed upon it at certain fixed positions. This shaft is operated by one of the half time gears.

Carburetor or Carburetter—A device wherein is vaporized, either by its own power, or by some mechanical means, such as spraying, and so takes up a certain amount of air, thus forming the explosive mixture.

Carbonize—The deposit of carbon upon the points of the sparking plug, or on the porcelain within the combustion-chamber. Heavy deposits are due to incorrect mixture, to bad lubricating oil, or to inferior gasoline. Under the very best conditions yet known a certain deposit is unavoidable, and, therefore, the sparking-plug, inside of the cylinder, combustion-chamber, piston and valves should be cleaned from time to time, in order to keep the engine in good condition.

Cell—An electrical cell, is a vessel complete with its contents, and a number of these form a battery, or a set of storage batteries. Each cell must contain positive and negative plates, and some form of electrolite. The current passes from one pole of the cell to the other, by means of the conducting wires outside the cell, the electricity doing its work during this passage. Cells are of two types, namely, primary and secondary, or "cells" of a storage battery or a "dry cell."

Chauffeur (Sho-Fur)—Operator of a motor car.

Chassis—The frame and power part of an automobile. Automobile without a body.

Change Gears—The transmission or system of changing the gears, gear box.

Circuit—The path of the electrical current arranged by the conducting material, or wires.

Circulating Pump—Used to circulate the cooling water. Of the centrifugal type, and operated by the engine.

Clutch—A device for connecting and disconnecting the engine from the transmission—usually placed in or on the face of the fly wheel.

Clutch Pedal—The foot pedal which connects and disconnects the clutch.

Coil—See Induction Coil.

Coil and Battery System of Ignition—In a battery the electricity is obtained by chemical means instead of mechanical means, as when a dynamo is used. The coil has nothing to do with the generation of the electric current, its function being to "gear up," intensify, or increase the pressure or transform the low-voltage primary current into a high-voltage secondary current to enable a spark to be produced across the air gap of the plug points

Compression—A term implying that the explosive charge of gas and air drawn into the cylinder on the suction stroke is subjected to a strong squeezing effect on the next stroke. The charge is pressed into a space about one-fifth the volume or space of that occupied by it on the suction stroke, equalling 80 lb. to 90 lb. compression per square inch. When a piston ring is defective or a valve leaks, the compression is weak and the motor loses power.

Compensating Gear—See "Differential."

Compression Tap or Cock—A small tap placed at the upper end of the cylinder, which tap can be opened to relieve the compression while the motor is started.

Condenser—An important part in a spark coil or high-tension magneto ignition machine. It consists of a series of waxed paper mica sheets interleaved with tin foil. Its function is to absorb the "back" or reverse current which occurs in the coil, and which, unless passed into the condenser, would interfere with the sparking.

Conductor—A material along which the electricity will readily pass, such as copper, platinum, steel, and, in fact, all metals.

Connecting Rod—The hinged, oscillating rod from the piston to the crankshaft.

"Contact Breaker"—The interrupter on a magneto. Also applied to the interrupter arrangement on the "make and break" igniter.

Contact-Screw—The small screw, having a platinum point, against which the trembler vibrates.

Contact Sector.—One of the Sectors in a timer or distributor.

Combustion Space—The space between the end of piston and head of cylinder.

Commutator, See timer.

Commutator is an expression sometimes met with in motor work. Commutator is really a piece of mechanism that reverses the direction which the current is flowing, and such is not fitted to a motor. "Contact-Maker" is what is generally meant.

Crank-Case—The case, usually formed of aluminum, which contains the cam shaft and main bearings. The base for the cylinders.

Crank-Shaft—The main shaft of the motor, cranked to receive the big-end bearing of the connecting-rod. Sometimes the fly-wheels are made to form portions of the shaft.

Current—The flow of electricity from one pole of the battery to the other.

Cut-Out, Muffler—A valve opening into the exhaust pipe of a gasoline engine at a point between it and the muffler, which when opened permits the exhaust gases to escape through it directly into the atmosphere instead of being forced through the muffler. Opening the cut-out relieves the engine of the back pressure. The cut-out is generally opened and closed by a linkage oiperated by a pedal.

Cylinder—The casting, forming a tube, in which the piston has a reciprocating motion.

Cylinders En Bloc—The four cylinders cast in one.

Cylinder Priming Cock—Usually placed in the head of the cylinder for injecting gasoline, also used for compression cocks.

Cut Out—Usually an opening placed on the exhaust pipe to permit the exhaust to pass out before reaching the muffler.

D

Dead Rear Axle—A rear axle that does not turn. Type usually used on double chain driven cars.

Demountable Tires—A new form of tire that is usually carried on the side of the car as a "spare" and is already placed on a steel rim and inflated ready to place on the wheel.

Direct Current—Electric Current where the current flows continuously in one direction. Unlike "alternating" current—the opposite.

Differential Gear also called a compensating gear, placed on the rear axle, also on a jack shaft transmission. It permits the inside wheel, when turniing a curve, to run slower than outside. There are two forms of differentials; the spur gear type and the bevel gear type.

Disc Clutch—A form of clutch made up of discs.

Dry Battery, called dry cells, primary cells. A series of primary cells which do not contain liquid electrolite.

Dynamo—A generator of electricity. A dynamo and a magneto differ in that the dynamo supplies a "direct" current whereas the magneto generates an "alternating" current. The dynamo is usually used on a motor car to light the electric lights and to recharge storage batteries and in some instances furnishes current for a jump spark coil. It is quite frequently used with low tension of "make and break" system of ignition.

Distributor—A timing device for making contact of both the primary and secondary wire at the same time for electric ignition. With a distributor only one coil with vibrator is used on a multiple cylinder engine. This coil does the work of the 4 or 6 or 8 or type engine may be. It is practically two timers or timing devices placed back to back, one breaks the primary current and the other the secondary. If both did not break at the same time the secondary would jump the space from one connection to the other.

E

Earth Connection, of return. This is an inaccurate term when applied to the wires, hence the "earth is not used at all. What is meant the electric circuits of a motor. The motor insulated from the road by the framework of the car is used as a return conductor so as to dispense with some of the wires.

E. H. P.—Electric Horse Power. 746 Watts—

E. M. F.—Electro Motive Force. The voltage. The pressure. Tension.

E. P. M.—Explosions Per Minute of a gasoline engine.

Electrode—The insulated part placed in the igniter of a low tension system of "make and break" ignition. One of the parts with platinum points where the spark occurs.

Electric Ignition—Any form of ignition by which the mixture in the combustion-chamber is exploded by means of an electric spark.

Electrolite—This is usually a fluid in a cell, and may be acid, alkaline, or neutral. The electrolite varies with the plates employed. The most common electrolite is composed of sulphuric acid, expressed by H-2 SO-4, made to the specific gravity recommended by the manufacturer of the particular cell in which it is employed.

Elements—The elements of a dry cell are the ingredients contained therein.

Electro-Magneto—The iron part in which the "armature" on a dynamo revolves. It is magnetized electrically and only when the dynamo is running.

Engine—The motor.

Exhaust Box—See Muffler.

Exhaust-Cam—The cam on the half-speed shaft which raises the exhaust valve at the correct moment, and keeps it open for the requisite length of time

Exhaust-Valve—The valve which is opened to allow the spent charge to escape from the cylinder.

F

Field—The winding of copper wire on the field magneto of a dynamo.

Fly-Wheel—A heavy wheel rotating without contact with anything save its axle, by the momentum of the periphery of which an even running of the motor is obtained, and the piston is enabled to complete the three non-effective strokes.

Flux, Magnetic—The number of lines of magnetic force that pass or flow through a magnetic circuit.

G

Garage—A place for storing an automibile. A building devoted to the storage and care of motor vehicles, particularly a building in which the business of storing, caring and supplying automobiles is conducted in a public manner.

Pronounced with the final g soft, the final a open, and the accent upon the last syllable.

Gear Box—The Transmission.

Ground—Connection of electric wiring to frame of car or metal part of engine.

Gasoline or Gasolene—(English, gas; Lat. al (eum) -oil) A light grade of petroleum.

H

Half Speed Shaft—The small shaft, revolved at one half the speed of the crank-shaft by means of any suitable gearing.

High-Gear—Combination of gears ordinarily used in running. The highest ratio of gearing—on some cars 2½ to 1 others 3 and 3½ to 1 ratio.

High Tension and Low Tension imply much the same meaning as when speaking of steam or water at high or low pressure. Thus the battery or accumulator only gives a current at low pressure which is not sufficient to produce a spark, but by sending the low-tension current through an induction coil the tension or pressure can be greatly increased so as to readily produce a spark.

Horse-power or H. P.—This has nothing to do whatever with the power developed by a horse—it is an unscientific way of defining power. A motor rated at 1 horsepower is capable of doing 1 **mechanical unit of work,** which is an equal to the power expended in lifting a weight of 33,000 lb. through a height of 1 foot in 1 minute of time. The French horse-power equals 32,549 foot pounds, and is thus less than the English standard.

Hydro Carbon Engine—A gasoline engine.

I

Ignition—The exploding of the mixture in the cylinder, or combustion-chamber.

Ignition-Cam—The small cam on the half-speed shaft which either causes a make and break of the current, or is notched to receive the nose of the trembler in timers of the mechanical vibrator type.

Igniter has various meanings. On "make and break" ignition the part that makes the spark. On high tension it sometimes means the spark plug and other call the "commutator" the igniter. The correct meaning should be the part that ignites the gas.

"Indicated" horse-power or I. H. P. is measured by taking an indicator diagram which shows the pressure of the explosion in pounds per square inch. For high-speed motors an optical device is used which plots out the pressure line on a photographic plate. From this the mean effective pressure during the stroke can be calculated.

Intermediate Gear—Combination of gears intermediate in power and speed between the low gear and the high gear.

Induced Current—The momentary current set up in a circuit by the proximity of wires conveying the primary current, but not connected with those wires.

Induction—An influence exerted by an electrical charged body, or by a magnetic field or neighboring bodies without apparent communication or connection.

Induction-Coil—An apparatus through which the primary current is made to pass close to the secondary wires, thus setting up the induced, or high-tension current.

Intensify—To increase, to render more intense—to intensify the voltage (pressure) means to increase the voltage.

Insulator—A material through which electricity cannot flow, for instance, porcelain, mica, india-rubber, fibre, vulcanite, glass, celluloid, parraffin-wax, silk, shellac.

Inlet Valve—The valve through which the explosive mixture is passed into the cylinder by the sucking action of the piston during the induction stroke.

Inlet Valve-Cage.—A housing used over an inlet valve for connection with intake pipe.

Insulation—The protection of wires, or leads, by some suitable material which is a non-conductor of electricity.

Intensity Coil—See "Induction Coil."

Internal-Combustion Engine—A type of engine in which the energy is developed directly from the fuel within the cylinder itself. In a steam engine the energy is developed in the boiler separate from the engine in a less direct manner.

J-K

Jump Spark—A spark which jumps from one terminal of the secondary coil to the other. See induction coil.

Jump Spark Coil—A high tension coil—double winding.

Jump Spark Plug—A plug used with the jump spark system.

Kilometer—⅝ of a mile.

L

Limousine—A closed type of body extending over the entire car.

Line of Force—The direction in which is assumed that the lines of magnetic force pass.

Laminate—Built up of thin plates of iron—"laminate core in a magneto."

Low Speed—The ratio of gearing in a transmission for running rear axle at the lowest speed.

Live Axle—Type generally used on shaft driven cars. Axle turns.

M

Magneto—A device operated mechanically and driven direct from the engine and which generates electric current but "alternating" instead of "direct." There are two forms; the Low Tension or the High Tension. The magneto from whence the armature draws its current are "permanent" magnets whereas the dynamo magnets are magnets only when the armature is revolving called "electro magnets."

Manifold—The system of piping for intake or exhaust to engine cylinders.

"Make and Break" Ignition—Low Tension system of ignition.

Magneto Ignition, Magneto Electric Ignition, or Dynamo Electric Ignition, all express the same, namely, that the electric current causing the spark is produced primarily from magnets, and rotating coils of wire forming the armature, these being the fundamental parts of a dynamo. The mechanical energy, used in rotating the coils, is converted into electric energy.

Magneto—Low Tension—A magneto with one primary winding on the armature, supplies electric current for the "make and break" system. A low tension also supplies current for a jump spark coil without a vibrator; the "contact breaker" or "interrupter" being placed on the armature of magneto instead of the vibrator. You always can be certain that when a coil is needed in conjunction with the magneto the magneto is a low-tension type.

Magneto—High Tension—A magneto with two windings on the armature; a primary and a secondary. The coil is dispensed with entirely. Generates a jump spark or high tension or high voltage or high pressure of electricity sufficient to jump across gap of the spark plug.

Mechanical Efficiency is the ratio between the indicated h. p. and the h. p. available for useful work at the engine shaft.

Missfiring—Term applied to missing of one of the spark plugs.

Mixture—The carbureted, explosive vapor.

Mechanical Valves—Applied to either the exhaust or inlet valves when operated by a cam or mechanical means. The exhaust valve is always mechanical whereas the intake is sometimes automatic and depends on the suction of the piston to open it.

Motor—The engine or motive power.

Muffler—A series of pipes usually made of sheet iron placed at the end of the exhaust pipe to silence the noise of the exhaust.

N

Negative Pole—Minus sign—The point to which the current returns after passing through the coil and contact breaker. Designated thus: —

O

Ohm—A unit of electrical measurement of resistance. The resistance the electric current meets in flowing through the conductor is measured in ohms.

Otto, or Four-Stroke "Cycle," is an expression often used in connection with gasoline motors. It means that the power is developed during a complete cycle of four strokes, the principle first adopted in the Otto gas engine. The complete cycle comprises four distinct operations, one occurring at each half revolution or every stroke of the piston; thus (1) suction stroke, (2) compression stroke, (3) impulse or firing stroke, and (4) exhausting stroke.

P

Petrol—Gasoline.

Piston—The round, sliding part, usually hollow, working in the cylinder and to which the connecting-rod is hinged.

Piston Rings—The split, expansive rings placed on the piston in suitable grooves and expanding against the walls of the cylinder, thus preventing leakage while permitting a free sliding movement of the piston.

Plugs—A device screwed into the combustion chamber or top of cylinder, made generally of porcelain with two platinum points, each being insulated from the other and being the terminals of the secondary current. Between these points a spark occurs and ignites the gas at the proper time. See spark plug.

Platinum Points—The small pieces of platinum secured to the contact-screw and to the trembler on the Jump Spark coil.

Porcelain—The insulating material of the sparking plug.

Positive Pole—This is marked thus: -|-. The positive pole is the terminal of the plate or element, whence the current starts to flow.

Port—Openning in the cylinder for exhaust or for the valves.

Pre-ignition—Ignition occurring earlier than intended.

Primary Battery—A series of either wet or dry cells depending upon chemicals for the generation of electricity, without charging from a dynamo or other battery.

Primary Coil—The winding of an induction coil through which the current from the battery circulates only.

Primary Wires—The wires, or leads, conducting the primary, or low-tension, current to the place, or places, where it is required for use.

Priming the Carburetor—Method of pushing float down in order to admit gasoline. Usually done just before cranking engine.

Propeller-Shaft—The drive shaft from transmission to rear axle.

Q

Quadrant—Usually applied to the quarter circle on which the spark lever and throttle lever is attached cn top of the steering wheel.

R

Retard—A decrease in the speed of. Uusually applied to "retarding the spark," meaning to set the timer back so that the ignition will be later or slower.

Reverse—Applied to change of gears for reversing motion of car—to drive backwards.

Rectifier—An electrical device for recharging storage batteries from alternating light circuit.

Radiator—A water tank with a system of tubes through which the water passes and is cooled—generally placed in front of the car so that air passes around the tubes when car is in motion.

S

Secondary Battery—A set of Accumulators which can be recharged when exhausted. A storage battery.

Secondary Coil—The winding in which the high-tension current is generated which is quite distinct from the primary current.

Secondary Wires—The wires, or leads, conducting the inducted, or high-tension, current to the frame of the motor and to the sparking plug.

"Selector"—The slot arrangement for the levers to be placed in when shifting gears on a selective transmission. Placed at the bottom of the lever.

Silencer or Muffler—An apparatus usually consisting of a round box through which passes a tube. The latter is perforated freely in that portion within the box, and is covered by a series of similar tubes. The spent gases pass through these holes into the next larger tube; through similar holes in that into the next, and so on. By this means expansion is gradual, and, in the end, the gases escape from the holes in the box, or outer tube, into the atmosphere more or less noiselessly.

"Six-Sixty"—A term frequently used on storage batteries, meaning 6 volts and 60 amperes capacity.

Short-circuiting—The failure of the current to traverse the proper circuit arranged for it by the wires, so failing to fire the mixture. This is caused by faulty insulation.

Spark—The spark which passes between the points of the sparking-plug.
gravity of 680 at 60 degrees F., becomes very highly explosive.

Spark Coil—A coil through which electric current is passed and intensified.

Spark Plugs—These are screwed into the side or top of the combustion chambers, the spark being produced at the terminals of the spark plug, jumping across the air space between the platinum points.

Storage Battery—See Secondary Battery.

Starting Crank—A crank for starting the engine.

Switch—A mechanical arrangement by which the electrical circuit is made or broken at will. This is often performed by removing, or inserting, a small plug or touche between two springs. Also by means of a revolving handle, in the case of a motor cycle.

Synchronise—Occurring at the same time. To happen at the same time.

Starting Plug—A small brass plug which fits into an opening on the dashboard and closes the circuit. When removed, the circuit is broken and no one can start the car.

Spark Control Lever—The central lever on the steering column. Pushing down on this advances the time of spark, and pulling up the lever retards the time of the spark

T

Terminals—The metal studs and milled nuts holding the conducting wires to the batteries, or accumulators, induction-coil, etc.

Throttle Valve Lever—The right hand lever on the steering column. Opened by pulling backwards. Closed by pushing forwards.

Timing—The production of the spark at exactly the right moment to give the best results, according to the speed at which the motor is working.

Timer—A cummutator for closing and opening the primary circuit, usually placed on the cam shaft.

Timing-Lover—The handle by which the timing is effected by means of moving the commutator, or other type of contact breaker.

Tonneau—The rear part of an automobile body provided with two or more seats.

Transmission—The gear box containing the change of gears.

Touche—The small plug used in the switch to complete the electrical circuit when required.

Trembler—The small vibrating spring used for making and breaking the primary circuit by falling into the notch in the cam of the half-speed shaft. If on the coil, the trembler makes and breaks the circuit by its vibrations, and is set in motion by magnetic influence upon it as the passing current magnetizes a bundle of iron wires in the center of the coil.

Tube Ignition, a small tube, usually of platinum—having its outer end closed, is screwed into the combustion-chamber. This tube is so placed that the flame of a blow-lamp, generally supplied from a separate and small tank of gasoline, acts upon it and causes it to become incandescent. Old method of ignition now out of date.

Two-to-one Gear—The gearing—usually consisting of two toothed wheels, one having exactly double as many teeth as the other—by which the half-speed shaft is caused to revolve, for the working of the exhaust-valve and the electric ignition.

V

Vaporizer—A form of carburetor.

Valve-Lifter—An additional lever by means of which the exhaust-valve may be raised and kept out of action, thereby reducing the compression and preventing the creation of a vacuum within the cylinder, so causing the inlet-valve to remain closed. With the exhaust-valve raised, most of the noise occasioned by the engine ceases, and the car, or cycle, will run quietly past a restive horse, by its own momentum.

Valve-Spring—The spiral spring passing over the stem of the valve by the action of which the latter is automatically closed.

Valve-Stem—The stem upon the valve on which the spring works, which stem projects from the mushroom-shaped head forming the valve and passes through the guiding block.

Volts—A term or unit indicating the pressure of the current. Thus we say that the pressure or voltage of an accumulator is 2 volts for each cell. The pressure of the sparking current may be as high as 10,000 volts. It is a unit comparable to the pounds per square inch when speaking of steam or water pressure.

The volt and ampere may be explained best as follows: assuming that the electrical current be a river, then the volt is the speed of the stream and the ampere is the quantity. Thus a narrow and shallow river might have a high speed of current but a low quantity of water, while a broad and deep one might have a low speed and great volume. So it is with electric currents.

Voltmeter—An instrument for measuring the E. M. F. or voltage of electric current in a storage battery.

W

Water Jacket—The jacket around the cylinder through which the water circulates.

Water-Cooled—System of cooling a gasoline engine with water.

Watts—The unit of electrical power obtained by multiplying volts by amperes flowing in a circuit. 746 watts equal 1 horse-power.

The Unit of Work represents the rate of energy of one ampere of current under a pressure of one volt and is equivalent to the product of the voltage multiplied by the amperage.

Wet-Cell—A battery using a liquid solution.

— The sign of the negative pole of a cell, or battery.

-|- The sign of the positive pole of a cell, or battery.

HOW TO USE THE SPECIFICATIONS ON PAGE 494.

If You Wish to Know how a certain car is constructed, read the specifications below, then turn to the index and find the page number of any part you do not understand and read up on it.

For Instance, suppose you wish to know what kind of a power plant any particular car has, say, the Regal—noting below, note that it says: "Model 20 has four cylinders, cast en-bloc, valves left side mechanical, are mechanically operated." Ignition "dual." Now, if you do not understand what "en-bloc" cylinder,. "mechanical" valves, "dual" ignition, etc., means, then simply turn to index and find page the information is on and read up.

If, in Addition to the Above Description, the Specification says: The clutch is of the "cone" pattern and the drive is a "shaft" drive, then simply turn to the index, then the page, and read up.

In This Manner you will not only learn the construction of all leading cars, but you will understand the "principle" of the construction of ALL cars.

Very Nearly All Cars Are Now Using "Dual" Ignition; that is, a battery and coil to start on, and a magneto to run on. (See pages 264-273, 194-217.)

Large Six-Cylinder Cars and Large Four-Cylinder Cars often have "Double" ignition. (See pages 269-217.)

NOTE:—By subscribing for one of the trade magazines (name and address given on page 459), the reader will find advertisements of all the different automobile manufacturers, and by sending for their catalogue the reader can study their construction. By referring to the index for subjects that are not clear and then turning to that subject in this instruction and reading up on same.

SPECIFICATIONS OF SOME OF THE LEADING 1912 CARS

Name of Car	Model	No. Cylinders	H. P.	Valves	Ignition	Drive	Transmission	No. Speeds	Clutch
Autocar	XXIV B	4-P	30.6	Inlet in head. mech.	Dual	Shaft	Selective	3 & R	Disc
Amplex *	——	4-P	—	No valves 2 cycle See page 127	Dual	Shaft	Selective on rear axle	3 & R	Disc
Brush	R-about	1-vertical	10	S-mech.	——	2-chains	Planetary	2 & R	Disc
Buick	"34"	4-P	—	O-mech.	Dual	Shaft	Selective	3 & R	Cone
Buick	"35"	4-P	—	——	Dual	Shaft	Selective	3 & R	Cone
Columbia	Knight	4-P	38	Sleeve See page 124	——	Shaft	Selective	4 & R	Cone
Cadillac *	——	4-singly	32.4	——	Delco See pg. 457	Shaft	Selective	3 & R	Cone
Chalmers*†	"36"	4-en-bloc	36	O-inlet L S. Ex.	Dual, Bosch	Shaft	Selective	4 & R	Disc
Dorris†	"G"	4-P	30	O-mech.	Dual, Bosch	Shaft	Selective	3 & R	Disc
Everett*†	6-48	6	48	S-mech.	Dual	Shaft	Selective	3 & R	Cone
E. M. F.	"30"	4-P	30	L. S-mech.	Dual	Shaft	Selective	3 & R	Cone
Flanders	"20"	4-en-bloc	20	L. S-mech.	Dual	Shaft	Selective	2 & R	Cone
Ford	"T"	4-en-bloc	20	R-mech.	Magneto	Shaft	Planetary	2 & R	Disc
Franklin=	"D"	4-singly	38	O-mech.	Dual	Shaft	Selective	3 & R	Disc
Hudson*†	"33"	4-en-bloc	33	L. S-mech.	Dual, Bosch	Shaft	Selective	3 & R	Disc
Haynes	Y	4-P	30	O-mech.	Dual	Shaft	Selective	3 & R	Disc
Hupmobile	——	4-P	20	L. S-mech.	Magneto	Shaft	Selective	2 & R	Disc
Knox	R-45	4-singly	40	O-mech.	Dual	Shaft	Selective	2 & R	Disc
Locomobile	"30"	4-P	30	O-mech.	Dual	Shaft	Selective	4 & R	Cone
Moline †	"35"	4-P	35	L. S-mech.	Double	Shaft	Selective	4 & R	Cone
Marmon	32-40	4-P	32-40	L. & R-mech.	Dual-Double	Shaft	Selective	3 & R	Cone
Maxwell	——	2-horiz.	16	Mech.	Dual	Shaft	Planetary	2 & R	Disc
Maxwell †	Special	4-singly	36	L. & R-mech.	Dual	Shaft	Selective	3 & R	Disc
Mitchell	"30"	4-P	30	O-mech.	Dual	Shaft	Selective	3 & R	Cone
Mitchell	"Big 6"	6	40	O-mech.	Dual	Shaft	Selective	3 & R	Cone
Oldsmobile	Limited	6-P	60	O-mech.	Dual	Shaft	Selective	4 & R	Cone
Oldsmobile	"Autocrat"	4-P	40	O-mech.	Dual	Shaft	Selective	4 & R	Cone
Overland ‡	59-T	4-singly	30	L. S-mech.	Dual	Shaft	Selective	3 & R	Disc
Overland ‡	61-T	4-singly	45	L S-mech.	Dual	Shaft	Selective	3 & R	Disc
Packard	"Six"	6-P	48	L. & R-mech.	Dual, Bosch	Shaft	Selective On rear axle	3 & R	Disc
Packard	"Thirty"	4-P	40	L. & R-mech.	See pg. 229	Shaft	Selective	3 & R	Disc
Pierce-Arrow	48	6-P	48	L. & R-mech.	See pg. 275	Shaft	Selective	4 & R	Cone
Peerless†	36-6	6-P	48	O-mech.	Dual	Shaft	Selective	4 & R	Band
Peerless†	33-4	4-P	40	O-mech.	Dual	Shaft	Selective	4 & R	Band
Regal	"20"	4-en-bloc	20	L. S-mech	Dual	Shaft	Selective	3 & R	Cone
Stoddard-Dayton†	Knight	Cast in threes 6-Cyl.	—	Sleeve See page 124	Dual-Double	Shaft	Selective	3 & R	Cone
Stoddard-Dayton†	"Special" and "Saybrook"	4-P	58 and 48	O-mech.	Double	Shaft	Selective	3 & R	Cone
Stearns†	Knight	4-P	40	Sleeve See page 124	Dual	Shaft	Selective	3 & R	Disc
Stevens-Duryea	AA	6-P	43.8	L. S-mech.	Double	Shaft	Selective	3 & R	Disc
Thomas	6-40	6-P	40	R. S-mech.	Double	Shaft	Selective	3 & R	Disc
White†	"30"	4-en-bloc	30	L. S-mech.	Magneto	Shaft	Selective	4 & R	Cone
Winton*†‡	"48"	6-P	48.6	R. S-mech.	Dual	Shaft	Selective	4 & R	Disc

* Self starting. † Long stroke motor. = Air cooled. ‡ "Offset" crank shaft.

"4 P or 6 P" means, 4 or 6 cylinders cast in pairs. **"O. I."** means, overhead intake valve. **"L.S. or R.S. Mech."** means, the valves are on the left or right side (see page 192) **"3 & R and 4 & R"** means, 3 or 4 speeds to transmission (see page 55, 56, 337, 338,) **"Knight"** and **"Sleeve"** means, a new type of engine (see page 124.)

INDEX

A

Acetylene gas 301
Acid, for storage battery 289
Accessories 464-465
Accelerator 141
Accumulator 279
Adjusting carburetor 148-153-151-460-363-365-368
Adjusting spark and throttle 364
Adjusting valves 437
Adjusting vibrator 443-444-371
Advantages and disadvantages of various systems of ignition 214
Aeroplane 484
Aeroplane engine 125
Air crafts 484
Air starter, (Chalmers) 456
Air starter, (Delco) 456
Air cooling 311-306
Air valve spring, adjustment 363
Aluminum soldering 452
Alignment of wheels 420
Alternating Current 287-215
Am-meter 189
Ampere 167
Anti-Freezing Solution 313-304
"Aplco," igniting and lighting system 297
Atwater-Kent, ignition system 193
Attaching tires 383
Autocar 494
Automobile, how to select 465
Automobile laws 468-475
Automatic inlet valve 94
Auto supplies 469
Automobile, electric 293
Automobile, steam 481
Axles, front 30
Axles, rear, floating type 32
Axles, rear semi-floating type 30
Axles, dead 30
Axles, live 30
Attention to a car periodically 341

B

Back firing and back kicking, causes of 162-354-359
Back pressure in muffler 359-362
Baffle plates 441
Balancing Engine 108
Ball bearing 37
Band brake 25
Batteries, general 279-292-165-168
Bateries, dry 165-168
Batteries, storage 169-279
Battery charging apparatus 286-288
Bearings, ball and roller 37
Bearings, for engine 38-90-433-435
Bearings, scraping 39-90
Bearings, tightning 112-438
Belt drive motorcycle 123
Bending tubing 451
Bent frame, how to straighten 419
Bevel gears drive 15
Bevel gears, differential 30
Blowout of tire 388-389
Blow pipe torch 451
Bodies 8
B. G. V. R. carburetor 144
Boilers, steam 481
Bosch ignition system 272-273-253
Brake, internal and expanding 26
Brake, foot 25
Brake, emergency 25
Brake, if fails 331
Brake, horsepower 478
Brazing 453
Brass cleaning 342
Brush auto 494
Building a garage 401-407
Buick auto 494
Burner, gasoline 481
Buying a car (second-hand) 371
Bushings 484
Butterfly throttle valve 137
Biplane 484

C

Cable, high tension 443
Cadillac auto 494
Cams 81
Cam shafts 81
Cam gears 83
Carbide 302
Carbon deposit, cause and remedy 113-431
Carbonized cylinders 431
Carburetors, general 130-460-156-84
Carburetor adjustments 363-365-368-148
Carburetor, troubles 353-152-148-460-151
Carburetor, flooding of 162-368
Carburetors, too much priming 137
Carburetor, effect of water in 153
Carburetor, concentric type 136
Carburetor, venturi 148
Carburetor, proper size, how to determine 154
Carburetor, heating 154
Carburetor, freezing 137
Carburetor, governor type 139
Carburetor, back firing, popping 162-354-359
Carburetor, side float 138
Carburetor, throttle valve 137
Carburetor, spray nozzle 130
Carter carburetor 155
Care of tires 395-344
Care of a car 341
Cause of smoke 441
Cementing a tube 393
Chassis—chains for tires 376
Chalmers, air starter 456
Chalmers auto 494
Changing speed 330
Change gear, levers 339
Charging a storage battery 288-286
Chamber, float 136-146
Changing to high speed 53-330
Circuit, path of 188-186-196
Circuit, grounded 172
Circuit, low tension 174
Circuit, high tension 177
Circuit, make and break 174
Circulation, water 305
Circulating pumps 305
City driving 461
Cleaning brass work 342
Cleaning carbon from piston 431-432
Cleaning car 342
Cleaning radiator 315
Cleaning upholstering 343
Clearance and tread 8
Clincher tires 373
Clutches, general 42
Clutch, cone 42
Clutch, multiple disc 46
Clutch, internal expanding 47-117
Clutch, leather, how to attach 446-366
Clutch pedal 326
Clutches, slipping 47-361
Climbing hills 330
Coasting 331
Coil, low tension 175
Coil, high tension 177
Coil, primary 175-173
Coil, vibrator 177
Coil, non-vibrator 225
Coil, master vibrator 192
Coil, induction 177
Coil, secondary 177
Coil, adjustments 371-444-190
Coil, troubles 349
Columbia auto 494
Combustion chamber 114
Commutator 100-446
Compensating gear 32
Compound for grinding valves 425
Compression, in general 114-95
Compression, loss of 95-356-367-424
Compression, leakage 369-371
Compression, how to raise 368
Concentric float 136
Cone clutches 42
Connecting rod, broken 421
Connecting rod 91
Condenser 195-250

Cooling 305-85
Cooling, air 306
Cooling, water 311
Cooling system troubles 314-363
Controller, for electric vehicle 293
Controlling the speed of engine........332-335
Copper gasket 443
Cracked cylinder 448-449
Crank case 84
Crank case, hot 360
Crank case, cleaned how often 369
Crank shafts 89-108
Crank shaft, bent 438
Crank pin 89
Crank lost, how to start 458
Current, alternating 221
Current, direct 168
Current, electric 167
Current, low tension 174
Current, high tension 177
Current, how produced 166-168
Current, secondary 177
Current, primary 170
Cut out, on exhaust pipe 418
Cycle, two 127
Cycle, four 77
Cylinders, in general 84
Cylinders, L-type 92
Cylinders, T-type 92
Cylinders, air cooled 312
Cylinders, water cooled 305
Cylinder bore, in meters 480
Cylinders, en-bloc 120
Cylinders, how cleaned 432-433
Cylinders, order of firing 108-110
Cylinder replacing 430
Cylinder oil 322
Cylinder cracked, how repaired...430-448-449

D

Daily attention to car 341
Degree of crank shafts 108
"Delco" starter 457
Demountable tires 378
Detaching tires 381
Diagram of wiring of various ignition systems 197-266
Dictionary 485
Difference between dynamo and magneto.215
Differential gears 32
Digest of laws 468-475
Digest of troubles 358-360
Direct current 168-286
Dirigible air craft 484
Disc clutch 46
Distributors 191-238-254
Dorris car 494
Double chain drive 11
Double ignition 217-269
Double dual ignition 268
Double spark magneto 274
Double tube tires 373
Don'ts for magneto 263
Draining the water in winter 313
Drilling holes and reaming 415
Drive, bevel 15
Drive, spur gear . : 38
Drive, chain 11-12
Drive, worm gear 31
Drive, jack shaft 4-56
Drive, motorcycle 123
Driving a car, pointers 461-330
Drive reduction 16
Dry cells 168
Dual ignition 194-217-460
Dual ignition, Bosch 272
Dynamos 171-215

E

Edison storage battery 291
Electrolyte for storage battery....284-285-289
Electro magnet 171
Electric current 168
Electricity, explanation of and principle..166
Electric lighting a car 295-297-296
"Elba" ignition and lighting system....296
Electric lighting, of gas lamps............303
Electric vehicles 293
Electric vulcanizing 396
Elliptical springs 23
Emergency repairs 458
Emergency tires 378-380
E. M. F. 494
En-block cylinders 120
Engine, gasoline 74
Engine, steam 481
Engine, two cycle 127
Engine, four cycle 77
Engines, for aeroplanes 125
Engines, marine 121
Engine, V-type 120
Engine, stationary 121
Engine troubles, in general , ,........358-112
Engine, refuse to start 358-104
Engine, starts but will not run 358
Engine, will not run fast 358
Engine, stops suddenly 358
Engine, stops slowly 358
Engine, misses explosion 358-362-354
Engine, does not deliver power 359
Engine, runs well, but car drags.........359
Engine, will not stop 359-360
Engine, fires in muffler 359
Engine, overheats 359
Engine, knocks 360-367-355-366
Engine, makes hissing noise...............360
Engine, runs well, but will not drive car..360
Engine, difficult to pull over.............360
Engine, hot crank case 360
Engine, piston ring leakage 369
Engine, heats 364
Engine, Knight make 124
Engine, repairs ....423 to 436
Engine, overhauling 423
Equipping a shop 408-409
Everett 494
Exhaust, mufflers 86
Exhaust, valves 93
Exhaust, smoky 441
Exhaust whistle 419-418
Exhaust, cut-out 419
Expanding ring clutch 47
Explosion in muffler 359-362
Explosion missing 433-446

F

Faure plates of storage battery..........280
Fitting muffler cut-out 418
Fitting exhaust whistle 418
Fitting magneto 419
Fitting piston rings 427
Fixing broken spring 416
Fire, cause of, how to extinguish........445
Flanders 494
Flash boilers 481
Flash generator 481
Float, chamber 146
Float, concentric 136
Float, side 138
Float, feed, principle of..................136
Float, simple form of 132
Float, cork 143
Float, copper ball 143
Float, leaky 164
Floating a storage battery, on the line..297
Flooding of carburetor 162
Fly wheel, (removing) 75-361
Fly wheel, fan in 309
Foot brake 25-326
Forced circulation of oil 318
Forced circulation, water 305-310
Forced air draught 311
Forced feed lubrication 321
Ford auto 494
Ford magneto 276
Formula, horse power 477-479
Fouling of plugs 189
Four cycle explained 77
Four cylinder engine 116
Four cylinder coil 187
Four cylinder wiring diagram 266
Four speed selective transmission 58
Freezing solution 313-304
Freezing in carburetor 153
Friction disc clutch 65
Frost on wind shield 362
Fuel, too much is indicated by smoke....149
Files, how to use 413
Firing in muffler 359
Firing order of multiple cylinder engines 108
Foot pedals 336-326
Frames 6
Franklin auto 494
Frames, bent, straightening..............419

G

G. & A. carburetor 142
Gasoline engine, two cycle 126
Gasoline engine, four cycle 77-128
Gas generators 300
Gas tanks 304
Gas tips 303
Gaskets 447-448
Gas lighting 300
Gasoline, feed 159-419
Gasoline, pressure 159
Gasoline, gauge 417
Gasoline, generally 130-371-345
Gasoline, how made 130
Gasoline, gravity test 161
Gasoline, low grade 161
Gasoline, pipe, broken 419-455
Gasoline, how converted into gas 145
Gasoline, storage 463
Gasoline, no flow of 163
Gasoline, water in, gives trouble........162
Gasoline, fire, how extinguished........131-445
Gauge, gasoline 417
Gauge, on dash 160
Gear, bevel 34
Gear, compensating 32
Gear, spur 36
Gear, worm and sector 19
Gear, differential 32
Gear, steering 18
Gear, shifting 51
Gear, case 15
Gears, removing 419-421
Generator, electric current 171
Generator, lighting of lamps 299
Generator, gas 300
Gnome engine 125
Governing devices 100-139
Governor, centrifugal 100-139
Governor, Packard, water 139-141
Gravity, feed lubrication 317
Gravity, gasoline feed 159
Grinding valves 425-95
Grinding vibrator screws 442
Grinding valves, how often 369
Ground wire 172
Garage, how to build 401-407
Garage, for home 401
Garage, for business 406
Garage, how to equip 407-411
Garage, prices to charge 412
Garage, time of year to open 412
Grades, how to find 480
Grounding the circuit 172
Gravity feed 159
Grips on chains 376

H

Half elliptic spring 23
Handling a gasoline car 327
Hardening steel 454
Haynes auto 494
Heat, cause and remedy 314
Heat, from carburetor 360
High speed, changing to 330
High tension, current 177
High tension, coil 177
High tension, magneto 237-233
High tension, wiring diagram 176
Hill climbing, secret of changing speed early 331
Hill climbing, retard spark 335
Hot crank case 360
Hot engine 364
Hot radiator 314-359-360
How to use tools 413
How to determine size carburetor to use..154
How to read a taximeter 479
How to select a car........465
How to select a second hand car........371
How to find grades 480
Horse power, examples and formula..477-479
Hudson auto 494
Hupmobile 494
Hydrometer 283

I

Igniters, make and break 170-222
Igniters, low tension 174-222
Igniting, old style hot tube........166
Ignition, advantages—disadvantages of various systems 214
Ignition, battery 279
Ignition, circuits 188
Ignition, coil 175-176
Ignition, low tension magneto 219-221
Ignition, high tension coil 177
Ignition, high tension magneto 237
Ignition, control of speed 141-182
Ignition, synchronous system 192
Ignition, dual system 194-217-272
Ignition, Splitdorf dual 460
Ignition, double system 194-217
Ignition, troubles ....348 to 352
Ignition, testing 188
Ignition timing 207
Ignition, with master vibrator.192-215-275-231
Ignition, with distributor 191-238
Ignition, troubles 188-348-442
Indicator of piston stroke 436
Induction, coils 177
Inflation pressure 394
Information 459
Inlet valves, general 93
Inner tube repairs 345-373
Inserting screws 421
Insurance 446
Insurance, accident 446
Insurance, life 446
Intake valves, mechanical 94
Intake valves, automatic 94
Internal expanding clutch 47-117
Iron soldering 451
Irreversible steering gear 21

J

Jacket, freezing 313
Jacket, water (cracked)........305-448-449
Jack shaft 10-14
Jump spark ignition. 177

K

Kerosene treatment 426
Keys 414
Kit of tools for touring 464
Kingston carburetor 156
Kilometers 480
Knocking in cylinder of engine........112-433 360-367
Knox auto 494
Knight engine 124

L

"L" head cylinders 92
Lamps, gas tips, how to clean........303
Lamps, gas 301
Lamps, lighting by electricity 295-299
Lighting a car (electric) 295
Lighting a car (gas) 300
Lathe for shop 409
Laws of all states 468-475
Leaks of gasoline 162
Leak of carburetor float 164
Leaking oil 419-449-455
Leaks in radiator 315
Leaks in cylinders 424
Leakage of compression 369-371
Lengthening valves 422
Lever, all makes of cars how shifted........338
Levers, spark and throttle control........417-334 365
Leather fitted clutch, cone type........47-446
Lifter valve 422-480
Lines of force 245
Limousine 68
Locomobile 494
Loose bearings 438
Loose gear wheels 417
Loose control levers 417
Loose connections 442
Loss of power, cause and remedy........361-369 114-371
Locking nuts 417
Loss of compression, cause and remedy..114 371-356-367-424
Low tension, circuit 174
Low tension, coil 175
Low tension, magneto 221
Low tension, igniter 174
Low tension, ignition 174
Low tension, make and break 174
Lubricants 322
Lubricators 317
Lubricators, gravity 321-317

Lubricators, pressure 317
Lubricators, splash 321-318
Lubricators, force feed 321-318
Lubrication, genearlly 320-343-317
Lubrication, insufficient, how shown . ..324
Lubrication, how to test.................323

M

Making lever rods 415
Machinery for shop 407-411
Magnetism, explanation 245
Magneto 217
Magneto, ignition 216
Magneto, principle of 221
Magneto, low tension 221
Magneto, high tension 237
Magneto, fitting 419-423
Magneto, Remy 264
Magneto, Splitdorf 460-282-257
Magneto, Bosch 272-273-274-253
Magneto, pointers 262
Magneto, distribution of current 244
Magneto, setting of 237
Magneto, timing 261
Magneto, how to detect faults and troubles 369-352
Magazines, trade 459
Make and break system of ignition..222-364
Manifold, intake 150
Master vibrator coil 192-215-275-232
Manufacturers 459
Maxwell 494
Marmon 494
Mechanically operated valves 94
Measurements 480
Metres 480
Milimetres 480
Methods of producing electricity 165
Mitchell 494
Mixture, generally 153-164
Mixture, for carburetor 153
Mixture, too rich or poor, remedy..153-149-164
Mixture, throttle opened too fast gives poor 149
Mixture, faint blue flame 149
Mixture, yellow flame 149
Mixing chamber 146
Miscellaneous troubles 355
Misfiring 370--433
Misfiring, commutator 446
Misfiring, defective coil 362-358
Misfiring, defective mixture 370
Misfiring, faulty vibrator 190
Misfiring of engine 189-431
Moline 494
Motor starting 327
Monoplane.... 484
Motor,- knocking, causes 433-112
Motor-cycle 123
Muffler 86
Muffler, explosion in 359-362
Muffler, smoke from, causes. 149
Muffler, black smoke, too much gasoline.149
Muffler, white smoke, too much lubricating oil 441
Muffler, cut out 419
Muffler, exhaust 419
Multiple connection of battery 170
Multiple, cylinder, order of firing.........108
Multiple disc clutch 46
Multitubular boilers 481

N

Negative pole 169-279
Negative plates 277-279
Noises, unusual 355-366
Noises, hissing 360
Non-conductor 166
Non-freezing solution 304-313
Non-vibrator, coil 229
Non-skid tires 376
Nozzle of carburetor 146
Nozzle, spray 146
Nozzle, single jet 144
Nozzle, double jet 144
Nozzle, multiple jet 144
Nuts, how to remove when stuck 417
Noisy valves 437

O

Oils 320-322-371
Oil, leaking 449
Oil, poor 322
Oil, testing 323
Oils, general use 320
Oil, using too much, evils of 324
Oilers, various types 317
Oldsmobile 494
Operating a car 327-365
Overland 494
Overheating, ...314-359-360
Overhauling the engine 423

P

Packing gaskets 448
Packard 494
Packard water governor 140
Packard ignition system 229
Painting rims 394
Paint for radiators 455
Papers, trade 459
Parallel connections 171
Parts of gasoline engine 78-87
Passing a car, rules of the road 461
Pedals, for clutch 326-336
Pedals, for accelerator 326
Peerless 494
Pierce Arrow auto 494
Pierce Arrow ignition system 275
Pipe, gasoline broken 419-455
Pipe, inlet 97
Pipe, exhaust 97
Pistons 91-424
Piston rings 91-424
Piston rings, leaky 113-424-369-356
Piston rings, fitting new 427
Piston rings, stick remedy 113
Piston stroke indicator 436
Piston, V groove 441
Planetary transmission 59-325
Plante Type, storage battery 280
Plates, positive 279-277
Plates, negative 277
Plates, baffle 441
Plug troubles 350
Pneumatic tires 376
Pointers in car driving 346-347
Poles, positive 169-279
Poles, negative 279-169
Policy for insurance 466
Poor oil—effect 322
"Porcupine" system of cooling............312
Positive plates 277
Poppet valves 93
Pounding in engine, how caused...........112
Power for shop 409
Power, horse 477
Premier 494
Pre-ignition 113-363
Primary cells 165
Primary wire on induction coil...........177
Primary wire on low tension coil..........170
Priming carburetor 137
Pump, circulating 305
Principle of electricity 166
Progressive transmission 51-325
Propellor shaft 15
Propellor drive 15
Pump, circulating 86-310-305
Pump, oil 318
Pump, tire 375
Pump, connections 421
Puncture, how repaired 377-393
Pressure of tires 394
Pressure of current 167
Platinum points 442
Platinum pitted 442-445
Platinum points, how to grind............442

Q

Questions asked and answered............361
Quick detachable tire 378-379

R

Radiator paint 455
Radiator, various types 305-309
Radiator, tubes 308
Radiator, tubular 308
Radiator, cellular 308
Radiator, honey comb 308
Radiator, clean with soda 315
Radiator, leaks, how repaired 315
Radiator, air-bound 357
Radius rod 15
Ratio of drive 16
Reaming 415
Rectifier for charging ignition storage battery 287

Regal auto ... 494
Remy magneto ... 264
Repair tube ... 392
Repairing ... 413
Repairing connecting rod ... [illegible]1
Repair, valves ... 422
Repairs, emergency ... 458
Remy ignition and lighting ... 298
Removing tight nuts and screws ... 418
Removing gears ... 419-421
Remagnetizing magneto ... 242
Refitting platinum points ... 445
Repair of tires ... 388-389
Repair of engine ... 423-436
Repair of broken spring ... 455
Repair shop ... 406
Repair shop, how to build ... 406
Repair shop, tool equipment ... 407
Repair shop, prices to charge ... 412
Replacing cylinders ... 430
Replacing cracked cylinders ... 448-449
Rings, piston ... 427
Rims, tires ... 378-379-380-383
Rod, radius ... 15
Rod, torsion ... 16
Road signals ... 462-461
Rules ... 480
Running the engine, pointers ... 328
Rusting a crack in cylinder ... 361
Roller bearings ... 37
Rubber tires ... 376
Rules of the road ... 461-462

S

Sand holes ... 426
Schraeder valves ... 375
Schebler carburetor ... 460
Screws and studs, tight ... 416-418
Scraping a bearing ... 433
Screws, vibrator ... 44[illegible]
Second hand cars ... 371
Secondary battery ... 279-169
Secondary, current ... 179
Secondary, coil ... 177
Secondary, winding ... 177-248
Selecting an automobile ... 465-371
Selecting a carburetor ... 154
Selective transmission ... 325-56
Selectors of various cars ... 337-338
Semi-floating type of axle ... 31
Semi-elliptic springs ... 23
Self starter for engine ... 456
Self induction ... 187
Series connections ... 171
Series multiple connections ... 171
Serpollett ... 482
Setting valves ... 436
Shaft drive ... 15
Shellac, how to use ... 449
Shifting levers ... 337-58
Shock absorbers ... 24
Short circuit ... 188
Shop for repairing ... 400
Single coil with multiple cylinders ... 216
Side float carburetor ... 138
Size tires to use ... 394
Signals for road ... 462-464
Skidding, how to prevent ... 345
Sleeve valve engine ... 124
Sliding gear transmission ... 51
Slowing down ... 464
Smoke, cause of ... 441
Smoke, from muffler, causes ... 441
Soldering ... 450
Solid tire ... 376
Spark, control ... 181-325
Spark adjustments, advance heats engine ... 364
Spark and throttle adjustment ... 365
Spark levers ... 334-365
Spark, make and break ... 170-223
Spark, coils ... 170-178-229
Spark, timing ... 181-261
Spark coil, vibrator of ... 178
Spark gap ... 240
Spark lead, advance after throttle ... 365
Spray nozzle ... 146
Steam automobile ... 481
Spark plugs ... 100-185-189
Spark plug, missing ... 433
Spark plugs, poor compression, if not tight ... 371
Spark plugs, points should be 1-32 apart and 1-50 ... 185-262
Spark plugs, sooting, too much oil ... 189
Spark ignition, advance ... 365
Spark timers ... 181
Specifications of all 1912 cars ... 494
Speed control ... 335-141
Splash lubrication ... 321
Splitdorf ignition ... 232-460-257
Sprayer for painting radiator ... 455
Speed control ... 332-335
Spray nozzle ... 146
Springs, on car ... 23
Spring, air valve ... 133
Spring, broken, how to repair ... 416-455
Sprocket, worn ... 417
Stanley steam plant ... 483
State laws ... 468-475
Starting car without cranking ... 458
Starting devices ... 456-457-458
Stearns auto ... 494
Stevens-Duryea ... 494
Steam vulcanizing ... 399
Stems, valve ... 422
Sticking vibrator ... 444
Steel hardening ... 454
Stoddard-Dayton ... 494
Storage for gasoline ... 463
Stopping ... 464
Steam, car, white ... 482
Steam boilers ... 481
Steam burners ... 481
Starting the engine ... 327-332
Steam engine ... 481
Steering devices and steering a car ... 18-330
Straightening a frame ... 419
Stepney spare wheel and tire ... 380
Storage batteries ... 279
Storage batteries, plates ... 280
Synchronous system ... 192
Syringe hydrometer ... 283
Stripped nuts ... 418
Supplies ... 459-464-465

T

"T" head cylinders ... 92
Tables for horse power ... 480
Taximeter ... 479
Tanks, for gas ... 304
Testing oil ... 323
Test for compression ... 115-367
Testers for storage battery ... 288
Thomas ... 494
Tickler on carburetor ... 137
Time to open garage ... 412
Timer ... 103-181
Timer, worn ... 442-352
Timer, cause of missing ... 446-442-352
Throttle, valve ... 99-145-142
Throttle, lever ... 185-334
Thermo-syphon, cooling system ... 306-311
Timing, valves ... 207-439
Timing, ignition ... 181-261
Timing devices ... 180
Three point suspension ... 23
Timing magneto ... 261
Tires, pneumatic ... 373
Tires, solid ... 376
Tires, rims ... 378-379
Tires, clincher ... 373
Tires, quick detachable ... 378-379
Tires, Stepney spare wheel ... 380
Tires, demountable rims ... 380
Tires, general care ... 395
Tires, blow outs, cause ... 389-391
Tires, proper inflation ... 394
Tires, damage, common cause ... 386
Tires, clincher, how to remove ... 373
Tires, clincher, how to put on ... 373
Tires, punctures ... 377
Tires, how to insert tube ... 375-387
Tires, how to repair punctured ... 377
Tires, temporary repair ... 388-389
Tires, of cases ... 387
Tires, tools for repair ... 388
Tires, vulcanizing ... 396-399
Tires, valves ... 373-375
Tires, emergency ... 378-380
Tires, attaching ... 381
Tires, troubles ... 386
Tires, tube repairs ... 392
Tires, pump ... 375
Tires, non-skid ... 376
Tire pressure ... 394
Tools for tires ... 383

Tools, how to use 383-413-407-411
Tools for touring 464-465
Torch 451
Torsion rod 16
Torque rod 16
Treatment of kerosene 426
Transmission 51
Transmission, progressive type 51-325
Transmission, selective type 54-325
Transmission, planetary 59-325
Transmission, levers 337-338-58
Transmission, selectors 337-58
Tread of wheels 8
Troubles, a complete digest, causes and remedies 348-358
Truing up wheels 420
Table of tire sizes to use................395
Troubles of piston rings 427-371
Tubes, inner 373
Turning corners 461-462-464
Two-cycle gasoline engines 127

U

Upholstering 342
Upkeep 371
Universal joints 48
Unit power plant 117-118
Using tools 413
Useful rules 480

V

Valves, general 81-93
Valves, by pass 126
Valves, gear four-cycle 70
Valves, lifter 422
Valve, inlet 80
Valve, exhaust 81
Valve, timing 102-207-439
Valve, springs 422
Valve, grinding, how to 95-425
Valve, grinding in cages 425
Valves, inlet, various types 92
Valves, leaky, weak explosions 424
Valves, stems 422
Valves, lengthening 422
Valves, weak springs 422
Valves, bent 422
Valves, heads 422
Valves, setting 436
Valves, grinding compound 425
Valves, noisy 437
Valves, adjusting 437
Valves, mechanically operated 94
Valves, sleeve 124
Valves, automatic 94
Valves, throttle 185
Valve, tire 373-375
Valve, inner tube 373-375
V-groove piston 441
Venturi, carburetor pipe 147
Vibrator, adjustment of 190-230
Vibrator, coil 178
Vibrator, coil diagram 176
Vibrator, coil ignition 179
Vibrator, electric 179
Vibrator, mechanical 179
Vibrator, screw 442
Vibrator, sticking 444
Vibrator, master 194
Voltage 167
Volt meter 285
Vulcanizing 396-399
Vulcanizing, electric 396
Vulcanizig, steam 396

W

Water circulation 307
Water in cylinder, remedy 361
Water cooling for cylinders 307-305-363
Water in carburetor 162
Water jacket leaks, repairs 315
Washing car, instructions 342
Wheel puller 420
Wheel alignment 420
Wheels, gear, loose 417
Wheels, lining up 420
Wheel base 8
Wheel, steering 20
White 494
Whistle, exhaust 413
White steam car 482
Winton 494
Winding, primary 175
Winding, secondary 178
Wiring, diagrams 266
Wiring, a car 441-295
Wiping a joint 451-453
Worm and sector steering 18
Worm and worm steering 19
Worm steering pin and rod 414
Worn sprocket 417
Worn timer 442
Work bench 407
Words and terms explained 485

Y

Zeppelin, airship 484

IF YOU ARE PLEASED WITH THIS BOOK SHOW IT TO YOUR FRIENDS, TELL THEM WHAT YOU THINK OF IT—WE WILL APPRECIATE THE FAVOR

Printype
OLIVER
Typewriter

The Only Writing Machine in the World That Successfully TYPEWRITES PRINT

—17 Cents a Day!

The Printype Oliver Typewriter, which has crowded ten years of typewriter progress into the space of *months* is now offered to the public for *17 cents a day*.

—Offered at the same price as an *ordinary* typewriter—*payable in pennies!*

The commanding importance of *Printype* is everywhere conceded.

For who does not see what it means to make the world's vast volume of typewritten matter *as readable as books or magazines!* The Printype Oliver Typewriter is equipped with beautiful Book Type, such as is used on the world's *printing presses*.

Printype is distinguished by marvelous clearness and beauty. It does away with all strain on eyesight which the *outline* type imposes. Printype puts life and style and *character* into typewritten correspondence. It makes every letter, every numeral, every character *"as plain as print."*

The complete story of *Printype* has never before been told. Here it is:

The Real Story of Printype

The idea from which "Printype" sprung resulted from the success of our type experts in equipping a typewriter used in our offices to write "The Oliver Typewriter" in our famous trade-mark type just as the name appears on the outside of the machines and in all Oliver publicity.

The beautiful appearance and marvelous clearness of the reproduction of our "ebony" trade-mark type, disclosed the possibility of equipping the Oliver Typewriter to *write the entire English language in shaded letters!*

We worked for *years* on the plan and finally succeeded in producing, for exclusive use on The Oliver Typewriter, the wonderful shaded letters and numerals known to the world as "Printype."

Meet "Printype"
You'll Like Its Looks

Ask for Specimen Letter and "17-Cents-a-Day" Plan.

Make the acquaintance of Printype, the reigning favorite of typewriterdom. Ask for a letter written on The Printype Oliver Typewriter, which will introduce you to this beautiful new type. We will also be pleased to forward the "17-Cents-a-Day" plan on request. Address Sales Department.

The OLIVER Typewriter Company
Oliver Typewriter Bldg.
812 Pine Street, St. Louis, Mo.

Dyke's Working Models of the Parts of the Automobile and Gasoline Engine

Everyone Reading This Book Ought to Have These Models

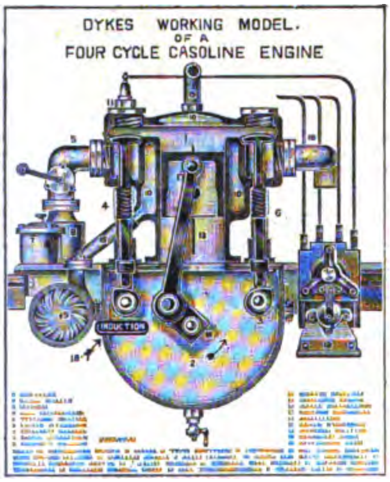
These models are used in conjunction with Dyke's Auto Encyclopedia. It would take years to learn what this Book and Models will teach you in a short time. This system is an advantage over actual shop practice.

A Modern System of Instruction originated by A. L. Dyke—the man who originated the first auto supply company in America and who published the first book on automobiles in America. He was also the original manufacturer of the first float feed carburetor made in America and has been associated with the auto industry since its inception.

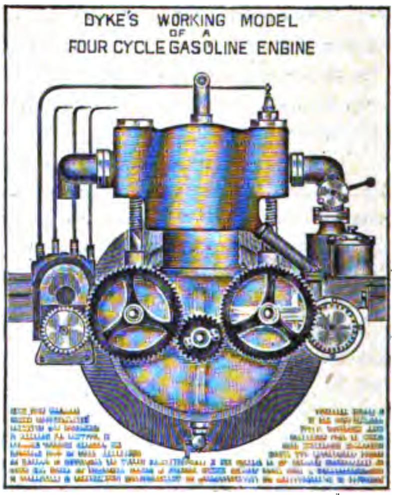
It is Impossible to Describe These Models so that you wil clearly understand what wonderful pieces of mechanism they actually are. They are not toys—every detail is there. **They Actually Work**—all moving parts made of real metal.

Complete as These Models are, they are small enough to be held in your hand and operated, enabling you to actually see every inside movement. **They represent the connecting link between study and practice,** giving you the benefit obtained by the man who learns by long years of practice—in a few minutes you will learn what it took him a long while to get from experience. I am willing to wager that these models will fascinate you so that you will play with and enjoy them more than any toy of your boyhood days, **because they teach** as well as **entertain.**

Note—When you learn the principle on which the Engine, Magneto, Carburetor, Differential and Transmission work—as the models herein described will teach you—then you will have **mastered the principle as used on all cars.** The construction may be slightly different on some cars, but the **principle** remains the same.



On this side the No. 1 Model (Engine) the Engine is seen in section.



The Model on this side represents the end view of Engine, or No. 1 Model.

No. 1—THE WORKING MODEL OF THE GASOLINE ENGINE

The Model Explains: The Cycle Principle—how the inside of an engine operates—how the valves operate—how to set the valves—how to time the ignition.

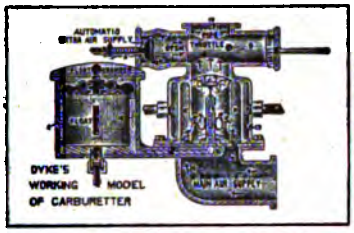
The Gasoline Engine is the motive power of the automobile. It is also the motive power of a launch and is becoming a popular power for general use on the farm and in shops, aeroplanes, and for other uses. It is the coming motive power of the world.

When you learn the principle on which the engine operates on this model—then you will understand the principle on which ALL Gasoline Engines operate. The construction may vary, but the principle is just the same—on all.

You Will be Enabled to Make Your Own Adjustments and repairs.

The Piston Goes Through the Complete Cycle, the piston rod moves, the gear wheel on the main shaft operates the half time shafts which control the valves, the inlet and exhaust valves open and close at the proper moment just as they do in full sized engines. **The Indicator, fig. 18,** tells you just what the engine is doing at all times—tells you when the piston is on the **suction stroke, compression stroke, ignition stroke** and the **exhaust stroke. Everything going on inside and outside is right there before your eyes.** It is possible to take down the model to practice actual timing of the valves, the problem that means so much in the economical development of power, yet understood by so few, even among self styled experts.

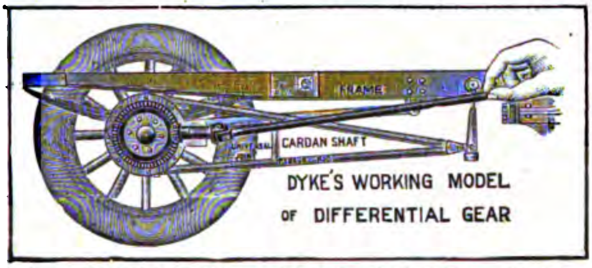
Full Data and Instructions Accompany Each Model


AUTOMATIC EXTRA AIR SUPPLY
THROTTLE
FLOAT
MAIN AIR SUPPLY
DYKE'S WORKING MODEL OF CARBURETTER

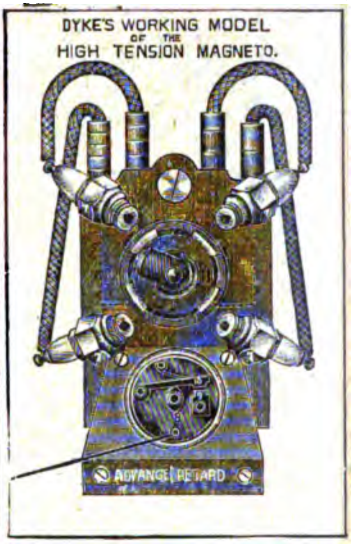
No. 2 - Model of the Carburetor. Only one side shown here.

No. 3 - The Magneto Model. Explains the principle of a Magneto in a few moments.

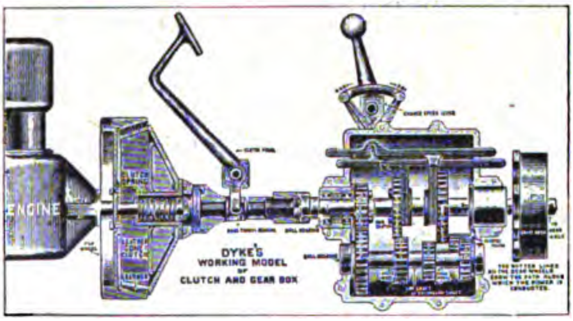
No. 2—This side shows the No. 2 Carburetor Model cut in half, explaining the inside construction and operation.



No. 4—Model of the Differential Drive Shaft, Universal Joint. TO OPERATE MODEL: Turn the drive shaft as shown in illustration, and the bevel gears and compensating gears will actually be seen in operation. The drive shaft, universal joint bevel gear, pinion and compensating gears are made of actual metal.



No. 3—Distributor side of Magneto also showing the Contact Breaker. The principle, construction, and how to set a magneto clearly explained. —If the armature is properly set the plugs will flash at proper time. Moving parts made of metal. The Distributor actually revolves and makes contact. The "Breaker" actually operates.

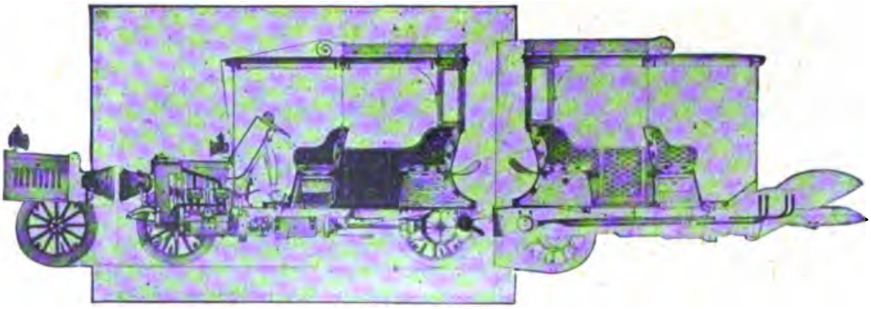


No. 5—The Transmission and Lever and Clutch Model. The moving parts are made of real metal.

No. 5 — The Transmission Model with Lever Shifting Arrangement and Clutch and Clutch Pedal. Explains in a few moments. Moving parts of actual metal. The clutch actually works — can be thrown in and out. The gears can actually be shifted with lever.

PRICE OF MODELS

Price of all models except the transmission (No. 5) model is **$1.00.** Transmission model **$1.25.** Add 10c to cover mailing. We are not responsible for packages lost in the mail, so to insure safety send 10c for registration.



This Manikin of an Automobile is Made on the Order of a Medical Chart—it unfolds and is divided into twelve parts. It explains the relation of one part of an automobile to another. A key telling the name of each part is included. This chart measures 23½ x 8¼ inches.

This Manikin is quite different from our **Real Working Models** and is not a ***Working* Model.**

THIS MANIKIN IS GIVEN FREE: To any purchaser of this book who orders the full set of models (5) at one time.

If Your Dealer Will Not Supply You, Write A. L. Dyke, Publisher, St. Louis, Mo.

(Free Catalog on Request)

Note—A Knight sleeve valve engine model will soon be ready.

Dyke's Home Study Course on the Automobile and Gasoline Engine

Illustration of DYKE'S HOME STUDY COURSE on the Auto and Gasoline Engine. Contained in a box made especially for keeping the parts of the course in place. Transmission and Differential Models not shown.

For the benefit of those who wish to learn the business of operating and repairing Gasoline Engines and the Automobile, we have prepared a complete home study course. It is sent to the student all complete in a special box, as shown, and which

CONSISTS OF

40 Instructions divided into 12 booklets.
175 Charts as contained in the 40 Instructions.
1 Working Model of Engine.
1 Working Model of Magneto.
1 Working Model of Carburetor.
1 Working Model of Transmission and Clutch.
1 Working Model of Differential.

THE EXAMINATIONS

There are Questions in the back of each Instruction. The student is required to write the answers on paper and then forward them to our examination department, who will correct any false understanding he may have gained and answer questions he asks. The student is graded and a handsome Diploma is awarded when he completes the Course.

Many students who have taken our course are now actively engaged in the auto repair business and as chauffeurs and repairmen are earning good salaries.

IF YOU ARE INTERESTED IN THE CORRESPONDENCE COURSE

It would be to your interest to write for our **Special Catalog on the Correspondence Course.**

We will show you hundreds of testimonials where our course has actually started young men as chauffeurs and many are now in the repair business.

The Price of this Course, complete, is but $15 00.

A 24 PAGE CATALOG

Describing this Home Study Course will be sent to you free if interested.

READ WHAT LEADING AUTHORITIES SAY ABOUT DYKE'S SYSTEM OF TEACHING BY MAIL

READ WHAT BARNEY OLDFIELD SAYS

New York City.

My dear Dyke:—

I am in receipt of your clever Auto Instruction, consisting of working models and Instruction Pamphlets.

Would say that this is the best proposition of its kind I ever saw.

If a person cannot learn all about the automobile with these instructions, then he cannot learn at all.

Every auto owner and those interested in gasoline engines or those contemplating the purchase of an automobile should have one, for it is a valuable instruction.

You know me,
BARNEY OLDFIELD

CHAS. E. DURYEA, READING, PA.

Dear Mr. Dyke:—

Your Auto Engineering Course is at hand and to say that I am surprised puts it mildly. It did not seem possible to get so much real information into such a course and yet keep it so concise and simple. I have long recognized that the hardest thing in connection with marketing the auto, is to educate the buyer to properly understand and use it. I have always struggled to design my goods as simple as possible so that the buyer could master them easily and get results that would please both him and myself, but many a time I have wished for just such a fund of information as you furnish so that I could help out the man who did not know and seemed unable to learn.

I am sure you will find a large demand for this course as soon as it is well known. I wish you every success.

CHAS. E. DURYEA

(The man who won the first American Speed Contest in 1895-96.
Mr. Duryea is a pioneer and well known as a leading authority.)

Address A. L. DYKE, Publisher, Exporter and Importer, 613-614 Roe Bldg., St. Louis, Mo.

This book should be returned to the Library on or before the last date stamped below.

A fine of five cents a day is incurred by retaining it beyond the specified time.

Please return promptly.

~~OCT 19 '51 H~~